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EIMERIA BUKIDNONENSIS, A NEW COCCIDIUM FROM CATTLE, AND OTHER COCCIDIAL PARASITES OF DOMESTICATED ANIMALS[1]

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TWO PLATES

The present report is the outcome of a survey conducted with the object of ascertaining the various forms of coccidial parasites found in domesticated animals. The survey was deemed necessary because, in spite of their recognized pathogenicity and common occurrence in domesticated animals in the Philippines, as reported by Schultz (1925), these organisms have not been studied systematically. Consequently, their identity, except that of one form found in a native cat and determined by Haughwout (1918) as *Isospora bigemina*, has long remained unknown. They have been merely referred to as "coccidia," as had been the practice elsewhere before the advent of modern protozoölogy.

The determination of these parasites was prompted by the following circumstances. For the last three years, usually during December and January, cases of bloody enteritis have been observed among young calves belonging to the dairy herd of the

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College of Agriculture, University of the Philippines, at Los Baños. Through the initiative of Mr. Felix B. Sarao, of the Department of Animal Husbandry, some of these cases were referred to the writer for diagnosis. A total of six animals were examined, and these were cow and carabao calves varying in age from one week to two months. The most important symptom presented was the frequent passing of liquid or semiliquid fæces containing rich admixtures of blood and mucus. The microscopic examination of the discharges revealed in every case the presence of coccidial oöcysts, which, as will be discussed below, represent two species of the protozoan genus *Eimeria*. The occurrence of the oöcysts in large numbers during the acute stages of the diarrhœa and their gradual disappearance at the onset of recovery (in the cases that recovered) show the etiological relationship of the parasites to the disease; which, in view of the principal symptom, is believed to be no other than the so-called red dysentery, or coccidiosis of cattle.

Recently, material has been obtained through the courtesy of Doctors Buencamino and Estores, of Manila, in the form of scrapings from the small intestine of a pup that died of a form of bloody enteritis. The case, according to Doctors Buencamino and Estores, was one of several pups belonging to the same litter that presented similar symptoms, which also ended fatally. At autopsy some of the animals showed intussusception in the region of the small intestine. The cases were correctly diagnosed as coccidiosis and, as will be shown below, the responsible parasite is a member of the genus *Isospora*.

ANIMALS AFFECTED AND SOURCE OF INFECTION

According to Smith and Graybill (1918) young calves (and this is probably true of pups and other young animals) become infected with coccidia soon after birth, but they may not show any manifestation of disease till several weeks later. This view brings up the questions: What is the source of the infection? How is it contracted? Regarding the first question, it has been shown that some adult animals, which may or may not have shown symptoms of coccidiosis during early life, may harbor coccidia without experiencing any apparent ill-effects from the presence of the parasites. Such animals act as carriers, and the coccidial oöcysts that they eliminate with their fæces constitute a source of danger to young susceptible animals. With reference to the manner of contracting the infection, it has also been shown that coccidial oöcysts are capable of retaining their viability for long periods even under adverse conditions. In view of this, it is most probable that young animals get the parasites by licking them up from the infected floors of their quarters or from the contaminated teats of the mammary glands of their mothers during the process of sucking.

Under certain conditions, adult animals that harbor coccidia and are, as already stated, apparently unmolested by the presence of the parasites, may also come down with acute symptoms of coccidiosis, as the following observations on two adult cats will show. These were animals that had been infected experimentally with surra organisms (*Trypanosoma evansi*) in connection with some other work in which the writer was engaged. They had previously been examined for coccidia and found to be infected with a species of the genus *Isospora*. The parasites were scarce, and the cats were apparently in the best of health. Soon after the appearance of the trypanosomes in the peripheral circulation, however, there was observed a sudden change in the character of the fæces of both animals. The evacuations became diarrhœic and bloody, and on examination they showed the presence of *Isospora* oöcysts in superabundance.

These are clearly cases of coccidiosis that were provoked by a lowering of the resistance due to secondary infections with surra. How often such provocations are brought about by other infectious diseases has not been determined, but it is now interesting to recall the observations of Schultz (1915, 1916) with reference to the common occurrence of coccidial organisms in the discharges of cattle and carabaos affected with rinderpest. This writer deserves much credit for his observations, but unfortunately he was tempted to ascribe the disease to the presence of these parasites.

METHODS

Collection of parasites.—The procedure adopted in the detection and collection of the parasites consisted mainly in emulsifying samples of fæces of individual animals in sterilized tap water, straining them through fine-meshed wire screens, and then collecting and examining the sediments after allowing the suspensions to stand in wide-mouthed cylinders for several hours or overnight. If a sample was found positive, it was diluted with a 2 per cent solution of potassium dichromate in order to allow the oöcysts to complete their development. In certain cases, in which the oöcysts were rare or from which large numbers of them were desired for critical study, a concentration method patterned after the direct centrifugal flotation (D. C. F.) method of Lane (1928) was used. The fæces were screened as usual, after the sediment had settled in a separatory funnel, the water was aspirated and replaced with concentrated sodium chloride solution. The mixture was shaken, and allowed to stand for at least thirty minutes in order to allow the oöcysts to float to the surface. The greater part of the salt solution was then removed, by opening the stopcock of the funnel, and was replaced with distilled water. The oöcysts were subsequently concentrated by centrifuging the contents of the funnel. The removal of the organisms from the concentrated salt solution is necessary because the high osmotic pressure of the latter causes the walls of the former to collapse sooner or later.

Measurements.—The measurements of the parasites were made with the use of a very carefully calibrated ocular micrometer. From twenty-five to forty oöcysts of each form of coccidium that was encountered in the survey were measured. In addition to recording the length and the breadth and giving the range in size of each species, it was thought advisable to conform to the recent practice and to the presumably more accurate method of expressing the measurements of parasitic Protozoa in terms of the mean, the standard deviation, and the coefficient of variation. These biometric constants, together with their probable errors, were calculated according to the following statistical formulæ:

Mean (M) $= \frac{\Sigma y}{n}$, in which y represents measurements (lengths or breadths) and n the number of oöcysts measured.

Standard deviation (S. D.) $= \sqrt{\frac{\Sigma y^2}{n} - M^2}$;

Coefficient of variation (C. V.) $= \frac{100 \times \text{S. D.}}{M}$;

Probable error of M $= \frac{\pm 0.6745 \times \text{S. D.}}{\sqrt{n}}$;

Probable error of S. D. $= \frac{\pm 0.6745 \times \text{S. D.}}{\sqrt{2n}}$;

Probable error of C. V. when C. V. is less than 10 $= \frac{\pm 0.6745 \times \text{C. V.}}{\sqrt{2n}}$;

Probable error of C. V. when C. V. is more than 10 =

$$\frac{\pm 0.6745 \times \text{C. V.}}{\sqrt{2n}} \times \left[1 + 2\left(\frac{\text{C. V.}}{100}\right)^2\right].$$

RESULTS OF EXAMINATIONS

The following were examined during the survey: Horses, cattle, carabaos, sheep, goats, pigs, dogs, cats, and chickens. One or more kinds of coccidia were found in the fæces of these animals, except the horse. There is no authentic record of these parasites in the horse, although Selan and Vittorio (1924) claimed to have seen an organism, which they named *Eimeria utinensis*, in the lungs and gall bladder of a horse in Italy. Before this, Pachinger (1886) and Sampson (1917) had described coccidial oöcysts in horses, but their descriptions, like that of Selan and Vittorio, are so meager that, as Wenyon (1926) states, it is impossible to tell if they were actually dealing with this group of parasites.

COCCIDIA OF CATTLE AND CARABAOS

Until recently, only one species of coccidium, *Eimeria zürnii*, has been recognized as being present in cattle and carabaos. Smith and Graybill (1918), in their studies on coccidial dysentery in calves in the United States, indicated the possible existence of more than one variety of these organisms in cattle. Their observations were later confirmed by Yakimoff and Galouzo (1927), who retained the name *E. zürnii* for the parasite, the oöcysts of which are roundish, with an average diameter of 17.1 microns and without a residual body in the sporocysts (Smith and Graybill's smaller type). For the egg-shaped oöcysts that have an average size of 31.5 by 21.6 microns and possess a residual body inside each sporocyst (Smith and Graybill's large type) they proposed the name *Eimeria smithi.*

Very recently Becker and Frye (1929) reported another coccidium from cattle in the United States under the name *Eimeria ellipsoidalis*. It is said to possess the following characters in common with *E. smithi:* There is a residual body inside each sporocyst, and the ratio of the average length to the average width is 1.47. It differs, however, from *E. smithi* in the following points: "(1) It (the oöcyst) is colorless and more inconspicuous. (2) The oöcyst wall is thinner, but does not thin out at the micropyle end proportionately to that of *E. smithi.* (3) It is ellipsoidal in shape. (4) It is considerably smaller in size" (20.0 to 26.0 by 13.0 to 17.0 microns; average size, 23.4 by 15.9 microns).

In our survey twenty-eight cattle and eleven carabaos were examined; seventeen of the former and five of the latter were found infected. *Eimeria zürnii* was present in only three cattle and in one carabao; the rest of the infected animals harbored *E. smithi*. The former is thus apparently rarer than the latter in adult animals, and yet in four of the six calves with dysentery it was the only organism involved. In the other two cases, although it was associated with *E. smithi*, it was present in predominating numbers. In the fæces of one bull that had been shipped to Manila from Bukidnon, Mindanao, for slaughter, an apparently new species was encountered together with *E. smithi*.

EIMERIA ZÜRNII (Rivolta, 1878). Plate 1, figs. 1, 2, 3 and 4.

The oöcysts are from spherical to ovoidal, with an average shape index of 1.10. They measure 13.5 to 20.2 by 12.3 to 18.0 microns. The average size of twenty-five oöcysts is $\frac{17.7 \pm 0.188}{16.1 \pm 0.151}$ microns,[1] with a standard deviation of $\frac{1.393 \pm 0.133}{1.121 \pm 0.107}$ and a coefficient of variation of $\frac{7.857 \pm 0.749}{6.962 \pm 0.662}$. The thickness of the oöcyst wall is uniform throughout, being about 1.1 microns. A distinct micropyle is not evident. The sporocysts are lemon-shaped and measure 7.8 to 11.2 by 5.1 to 5.8 microns. The oöcysts and sporocysts are devoid of any residual protoplasm.

EIMERIA SMITHI Yakimoff and Galouzo, 1927. Plate 1, figs. 5 and 6.

The oöcysts of this species are oval, with an average shape index of 1.51. They are larger than those of *E. zürnii*, measuring 28.8 to 39.6 by 19.8 to 27.0 microns. The average size of twenty-five oöcysts is $\frac{35.4 \pm 0.509}{23.5 \pm 0.324}$ microns, with a standard deviation of $\frac{3.780 \pm 0.360}{2.405 \pm 0.229}$ and a coefficient of variation of $\frac{10.678 \pm 1.038}{10.234 \pm 0.995}$. The oöcyst wall averages about 1.3 microns in thickness, except at the micropyle end where it is much thinner. In rare cases the oöcyst wall is extremely thin throughout, and because of this the question may be raised as to whether *E. ellipsoidalis* Becker and Frye, 1929, is a valid species or only an abnormal form of E. *smithi*. The sporocysts are lemon-shaped, 14.4 to 16.2 by 7.2 to 7.5 microns in size. Each sporocyst incloses a moderately conspicuous residual body.

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[1] The numerator stands for length; the denominator for breadth.

EIMERIA BUKIDNONENSIS sp. nov. Plate 1, figs. 7, 8, and 9.

As mentioned above, this form was found together with *E. smithi* in the fæces of a bull from Bukidnon, Mindanao, that was shipped to Manila for slaughter. The oöcysts differ very markedly, both in appearance and in size, from those of the other coccidia harbored by cattle and other domesticated animals. The only species to which it bears some resemblance is *Eimeria ekdysios* Triffitt, 1928, described from a millipede. In view of this, the question may be asked as to whether or not this organism is a true parasite of cattle, for it is possible that the host animal might have ingested with its food a millipede or a related arthropod harboring the parasite. The possibility of a case of spurious parasitism seems remote, however, for the number of oöcysts found in the fæces is very large. This would hardly be the case had the animal in question ingested one or even several millipedes, considering that the contents of the digestive tract of a bull are very voluminous. Even if it should turn out that this coccidium is not a true parasite of cattle, it should still be considered a distinct species, for it differs from its closest relative, *E. ekdysios*, in its oöcysts being much larger and in lacking a definite residual body within the sporocysts.

The oöcysts are yellowish to darkish brown and are uniformly pyriform, the average shape index being 1.37. They measure 46.8 to 50.4 by 33.3 to 37.8 microns. The average size of twenty-five oöcysts is $\frac{48.6 \pm 0.156}{35.4 \pm 0.135}$ microns, with a standard deviation of $\frac{1.155 \pm 0.111}{1.002 \pm 0.095}$ and a coefficient of variation of $\frac{2.375 \pm 0.227}{2.825 \pm 0.269}$. The oöcyst wall shows radial striations and is about 2 microns thick except at the micropyle end where it is very thin. The micropyle is conspicuous, being about 4 microns wide. The sporocysts are lemon-shaped and 14.4 to 21.6 by 9.0 to 11.7 microns in size (average, 19.2 by 10.1 microns). The sporozoites are more or less roundish or reniform. A definite residual body has not been seen either inside the oöcyst or in the sporocysts.

COCCIDIUM FROM SHEEP AND GOATS

Two species of coccidia have been reported from sheep; namely, *Eimeria faurei* (Moussu and Marotel, 1901) and *E. intricata* Spiegl, 1925. The oöcysts of *E. faurei* are described as being ovoid and measuring 20 to 40 by 17 to 26 microns; those of *E. intricata* are larger, 42 to 60 by 31 to 44 microns, and possess rough surfaces. Both forms show micropyles that are closed by distinct caps.

From goats only one species, *E. arloingi* Marotel, 1905, has been reported. The oöcysts measure 21 to 33 by 16.5 to 22.5 microns. It is believed, however, especially by Nöller, Schürjohann, and Vorbrodt (1922), who carried out cross-infection experiments with sheep and goats, that this form is identical with *E. faurei* of sheep.

EIMERIA FAUREI (Moussu and Marotel, 1901). Plate 2, figs. 1 and 2.

This appears to be a common parasite of Philippine sheep and goats. The oöcysts seen in both types of hosts are so similar that there is no question as to their representing the same species. They are ovoid, with an average shape index of 1.37. In the fresh state they possess a delicate yellowish tinge. They measure 25.2 to 39.6 by 18.0 to 25.2 microns. The average size of twenty-five oöcysts from a goat is $\frac{29.0 \pm 0.498}{21.1 \pm 0.294}$ microns, with a standard deviation of $\frac{3.695 \pm 0.351}{2.178 \pm 0.208}$ and a coefficient of variation of $\frac{12.715 \pm 1.257}{10.322 \pm 1.010}$. The oöcyst wall is about 0.8 micron in thickness and is provided at the micropyle end with a sort of bulging cap. The sporocysts are lemon-shaped, measuring 10.8 to 14.4 by 7.2 to 9.0 microns. A residual body is inclosed within each sporocyst.

COCCIDIUM FROM SWINE

Two types of coccidia of the genus *Eimeria* have been recorded from swine. One type produces larger oöcysts, measuring 50.0 by 35.0 microns, while another type produces smaller oöcysts, 18.0 to 24.0 by 15.0 to 20.0 microns in size. Opinion is divided among different observers as to the significance of these two kinds of oöcysts. According to Douwes (1921) and others, it is possible that they represent distinct species. Nöller and Frenz (1922) and Biester and Murray (1929) believe, however, that they belong to a single species, because of the occurrence of oöcysts of intermediate size.

In the fæces of Philippine swine three types of oöcysts have been encountered, as follows: Larger ones, 23.0 to 30.0 by 18.0 to 23.0 microns; smaller ones, 18.0 to 19.0 by 14.0 to 16.0 microns; and intermediate forms, 19.8 to 23.4 by 19.0 to 21.0 microns, in size. With such figures as these and without any knowledge of the complete life cycles of the three types of oöcysts, it is really not permissible to separate them into distinct species. There are, however, other criteria by means of which they may be differentiated and these include, among others, the shape of the oöcysts, the thickness of the oöcyst wall, the shape and size of the sporocysts, the shape and size of the sporozoites, and the presence and structure of residual masses of protoplasm. These structures have been taken into consideration in the study of a large number of oöcysts; and it has been found that the three types, except for their differences in size, resemble one another most closely. They are, therefore, taken to represent only a single species; namely, *Eimeria debliecki* Douwes, 1921.

The importance of this parasite has been either minimized or entirely overlooked; but, according to Biester and Murray, it is often the cause of intestinal disturbances in swine in the United States. In Philippine pigs it is very common and it would seem advisable to keep it in mind in the diagnosis of obscure cases of diarrhœa that are often observed in native animals.

EIMERIA DEBLIECKI Douwes, 1921. Plate 2, figs. 3 and 4.

The oöcysts are either oval, ellipsoidal, or nearly spherical, with an average shape index of 1.35. They measure 17.1 to 32.4 by 12.6 to 23.4 microns. The average size of forty oöcysts is $\frac{25.5 \pm 0.497}{18.9 \pm 0.375}$ microns, with a standard deviation of $\frac{4.809 \pm 0.351}{3.513 \pm 0.265}$ and a coefficient of variation of $\frac{18.829 \pm 1.52}{18.528 \pm 1.48}$. The oöcyst wall is uniform in thickness, being 0.8 to 1.4 microns. The sporocysts are lemon-shaped and capped at their rostrated ends. They measure 9.0 to 18.0 by 5.4 to 7.2 microns. A roundish, coarsely granular residual body is present within each sporocyst.

COCCIDIA FROM DOGS AND CATS

According to Wenyon (1926), dogs and cats in various parts of the world are parasitized with at least five different kinds of coccidia; namely, *Isospora bigemina* (Stiles, 1891), *I. rivolta* (Grassi, 1879), *I. felis* Wenyon, 1923, *Eimeria canis* Wenyon, 1923, and *E. felina* Nieschultz, 1924. The status of the first three species has been questioned, although they are said to differ not only in size but also as regards their localization in the tissues of the intestinal villi of their hosts. Wenyon and Sheather

(1925) give the dimensions of their oöcysts and sporocysts as follows:

Species.	Oöcysts.	Sporocysts.
	Microns.	*Microns.*
Isospora felis	39.0–48.0 by 26.0–37.0	20.0–27.0 by 18.0–21.0
Isospora rivolta	20.0–24.0 by 15.0–20.0	12.0–15.0 by 9.0–10.0
Isospora bigemina (large)	18.0–20.0 by 14.0–16.0	13.5–15.5 by 9.0–10.0
Isospora bigemina (small)	10.0–16.0 by 7.5–10.0	7.5–10.0 by 5.0– 8.0

In Philippine dogs and cats, one kind of *Eimeria* and two types of *Isospora* oöcysts have been seen. There can be no doubt that the *Eimeria* oöcysts that were recovered from a dog are those of *E. canis* and the *Isospora* oöcysts from the pup that died of coccidiosis, those of *I. rivolta*. On the other hand, the *Isospora* oöcysts from the two cats already referred to are difficult to determine, since they are intermediate in size between *I. felis* and *I. rivolta* (see Table 1). The smaller ones may be those of *I. rivolta*, but those measuring 27.0 to 30.6 by 23.4 to 27.0 microns do not appear to be either *felis* or *rivolta*. They may possibly represent either a new species or a new variety of either *felis* or *rivolta*. Their identification must wait until their complete development has been worked out.

TABLE 1.—*Measurements in microns of Isospora oöcysts from two cats.*[a]

Length.	Breadth.							Total.
	19.8	21.6	22.5	23.4	25.2	26.1	27.0	
21.6	1							1
25.2		1	2	1				4
26.1		2						2
27.0		2		12				14
28.0			9	11	2			22
28.8				2	1			3
30.6						2	2	4
Total	1	5	11	26	3	2	2	50

[a] Range $\frac{21.6 - 30.6}{19.8 - 27.0}$ microns. Mean $\frac{27.5 \pm 0.189}{23.3 \pm 0.142}$ microns.
Standard deviation $\frac{1.462 \pm 0.098}{1.491 \pm 0.100}$. Coefficient of variation $\frac{5.316 \pm 0.358}{6.399 \pm 0.431}$.

Haughwout (1918) has recorded the finding of coccidial oöcysts in a native cat under the name *Isospora bigemina*. That was at the time when the coccidia of dogs and cats were considered to represent only a single species. In view of their large size, 29.0 to 38.0 by 22.0 to 29.0 microns, it is possible that Haughwout was dealing with the oöcysts of *I. felis*.

EIMERIA CANIS Wenyon, 1923. Plate 2, figs. 7 and 8.

The oöcysts are oval, with an average shape index of 1.28. They measure 27.0 to 34.2 by 21.6 to 25.2 microns. The average size of twenty-five oöcysts is $\frac{30.4 \pm 0.282}{23.7 \pm 0.161}$ microns, with a standard deviation of $\frac{2.091 \pm 0.200}{1.196 \pm 0.114}$ and a coefficient of variation of $\frac{6.878 \pm 0.660}{5.046 \pm 0.484}$. The oöcyst wall is uniform in thickness and is usually provided with a visible micropyle. It incloses a large globular body which may be of the nature of a residual body. The sporocysts are lemon-shaped, 14.4 to 16.2 by 7.2 to 9.0 microns in size, and each incloses a roundish and coarsely granular residual body.

ISOSPORA RIVOLTA (Grassi, 1879). Plate 2, figs. 9 and 10.

The oöcysts are usually ovoidal, but sometimes they are ellipsoidal or nearly spherical; the average shape index is 1.23. They measure 18.0 to 23.4 by 15.7 to 19.8 microns. The average size of twenty-five oöcysts is $\frac{20.8 \pm 0.250}{16.7 \pm 0.169}$ microns, with a standard deviation of $\frac{1.852 \pm 0.176}{1.253 \pm 0.119}$ and a coefficient of variation of $\frac{8.869 \pm 0.846}{7.476 \pm 0.713}$. The oöcyst wall is uniformly thin and delicate and is easily distorted. The sporocysts, of which there are four, instead of two as in the members of the genus *Eimeria*, are roundish or ellipsoidal and measure 12.6 to 14.4 by 9.0 to 10.8 microns. Each sporocyst contains four club-shaped sporozoites and a large, rounded, granular, residual body.

COCCIDIUM FROM CHICKENS

Chickens have usually been thought to harbor only one species of coccidium to which the name *Eimeria avium* has been given. According to Tyzzer (1929), this name has been erroneously credited to Rivolta and Silvestrini (1873) and it was Rivolta (1878) alone who referred to this pathogenic coccidium of fowls under the designation *Gregarina avium intestinalis*. The latter name, being a trinomial, is however, not valid in a nomenclatural sense; hence, Tyzzer has proposed to adopt in its place the name *Eimeria tenella* (Railliet and Lucet, 1891). It also transpires from Tyzzer's investigations that instead of a single species there are four species of chicken coccidia; namely, *E. tenella* (Railliet and Lucet, 1891), *E. mitis* Tyzzer, 1929, *E. acervulina* Tyzzer, 1929, and *E. maxima* Tyzzer, 1929. These are said to differ among themselves not only in size but also in the character and location of the gross lesions that they produce in the intestines of their hosts, as shown in Table 2.

TABLE 2.—*Coccidia of chickens and their differentiation (after Tyzzer).*

Coccidium.	Size of oöcyst. *Microns.*	Character and location of gross lesions.
Eimeria tenella	$\frac{19.6-26.1}{16.3-22.8}$	At onset, hæmorrhage into cæca and lower intestine. Later thickening, milky whitening of cæcal mucosa, and cores of clotted blood.
Eimeria mitis	$\frac{14.3-19.6}{13.0-17.0}$	None.
Eimeria acervulina	$\frac{17.7-20.2}{13.7-16.3}$	Opaque grayish spots in upper intestine representing collections of oöcysts. When more extensive, the infected areas coalesce so that mucosa appears mottled.
Eimeria maxima	$\frac{21.4-42.5}{16.5-29.8}$	Thickening of small intestine most pronounced in middle portion. Blood-tinged exudate or small hæmorrhages.

So far oöcysts of only one type have been encountered in the fæces of native fowls. In view of their size, they have been identified as *E. tenella.*

EIMERIA TENELLA (Railliet and Lucet, 1891). Plate 2, figs. 5 and 6.

According to Tyzzer, this is the most pathogenic species of chicken coccidium. The oöcysts are generally ovoid or subspherical, with an average shape index of 1.11. In the fresh state they are either colorless or possess a greenish or yellowish tinge, probably depending upon the color of the intestinal contents. They measure 18.0 to 21.6 by 14.4 to 21.6 microns. The average size of twenty-five oöcysts is $\frac{19.8 \pm 0.202}{17.7 \pm 0.274}$ microns, with a standard deviation of $\frac{1.673 \pm 0.143}{2.263 \pm 0.194}$ and a coefficient of variation of $\frac{8.449 \pm 0.725}{12.785 \pm 1.128}$. The oöcyst wall is uniform in thickness and contains at its micropyle end a sort of plug that is quite conspicuous in some oöcysts. Within the oöcyst there is generally found a small globule, the nature of which is not known. The sporocysts are oval, rostrated at one end, and measure 9.0 to 11.0 by 5.5 to 7.0 microns. The sporozoites are reniform. A definite residual body has not been seen within the sporocysts.

DIFFERENTIATION OF COCCIDIAL OÖCYSTS

One other object of the survey, besides the enumeration of the coccidial parasites of Philippine domesticated animals, was to ascertain if the oöcysts of the various species of these organisms could be so differentiated from one another morphologically as to enable one to recognize them individually if they were mixed together or if encountered in animals other than their respective proper hosts; that is, the ones to which they are respectively best adapted. The reason for this is the uncertainty that prevails regarding the identity of some of the coccidia of domesticated animals and of man. Some parasitologists, who consider these parasites as nonspecific in the sense that they are interchangeable among a variety of different hosts, believe, for example, that the coccidia of man and of cats, dogs, and rabbits are identical. The same view is held with respect to those of cattle and swine. Other parasitologists, on the other hand, who maintain that these organisms are specific in the sense that a certain species of coccidium can infect only a single kind of host, or, at most, only a group of very closely related host species, believe that the coccidia of the different animals, including those of man, represent separate species.

It is of the utmost importance, as pointed out by Andrews (1927), to be informed definitely if these organisms are specifically related or not to their respective proper hosts, for we should know whether or not man is endangered by the coccidial parasites infecting his livestock and household pets, and also whether or not the latter are susceptible to the coccidioses that are common among many wild animals. Many attempts have been made to solve this problem by means of cross-infection experiments, the most recent being those of Uhlhorn (1926), Andrews (1927), and Corcuff (1928). Although many of these experiments (Andrews; Corcuff) have yielded results in favor of the specificity hypothesis, a few of them (Uhlhorn) have yielded just the opposite results, so that the question cannot be considered as definitely settled. It may be said in connection with cross-infection experiments that the results may be misleading unless, as also pointed out by Andrews, the following factors are taken into consideration: (*a*) The natural coccidial parasites of, (*b*) the interference of an acquired immunity by, and (*c*) the mechanical carriage of coccidial oöcysts by, the animals used in the experiments. The confusion that may result from these factors might be guarded against, however, if, in addition to employing only young and apparently noninfected animals in the experiments, one could distinguish morphologically the different kinds of coccidial oöcysts.

The morphological differentiation of coccidial oöcysts is an easy matter in some cases, but in others it may be difficult or even impossible without a full knowledge of their life histories. It is, of course, easy to distinguish the fully developed oöcysts of the members of the genus *Isospora* from those of the genus *Eimeria* by the number of sporocysts within each oöcyst and the number of sporozoites within each sporocyst, the isosporæ being disporocystid and tetrazoic and the eimeriæ being tetrasporocystid and dizoic. Among members of the same genus also differentiation may not be difficult, due to the possession by some species of characteristic features that readily mark them off from other species. For example, the caplike structure at the micropyle end of the oöcyst of *Eimeria faurei* and the very conspicuous micropyle of the deeply stained oöcyst of *E. bukidnonensis* at once separate these parasites of goats and sheep and of cattle, respectively, from those of the other domesticated animals. In other instances, however, as in the case of the coccidia of poultry and of cats and dogs, identification may be very difficult due to apparent morphological resemblances. In these cases a determination based on shape and size, as had often been done formerly, cannot be relied upon exclusively; otherwise, if an overlapping of sizes should occur, one would be led to consider as identical organisms that in reality represent separate species. The converse of this may also happen; that is, the oöcysts of a single species may be taken to represent two or more species, as in the case of *Eimeria debliecki* of the pig and of *E. lacazie* of the English sparrow, in which, as the recent observations of Boughton (1930) seem to indicate, there is a wide variation in the size of the oöcysts. In addition to (*a*) shape and (*b*) size, it is, therefore, necessary to note other factors, such as the following: (*c*) The thickness and appearance of the oöcyst wall; (*d*) the number, appearance, and size of the sporocysts; (*e*) the number and structure of the sporozoites; (*f*) the presence or absence and the structure, if present, of any residual protoplasm within the oöcyst after the formation of the sporoblasts (oöcystic residual body); and (*g*) the presence or absence and the structure, if present, of any residual protoplasm after the development of the sporozoites (sporocystic residual body).

These structures have been taken into consideration in the determination of the coccidial oöcysts dealt with in this paper. In Table 3 are presented the distinguishing features of the various species. By reference to the table it will be seen that, with the exception of the isosporan oöcysts of the dog and cat and of *Eimeria smithi* and *E. debliecki*, their differentiation is comparatively easy. As already stated, *E. faurei* of sheep and goats is readily distinguished by the possession of a caplike protuberance at the micropyle end of the oöcyst wall and *E. bukidnonensis* by the shape and size of the oöcysts and the presence of a very conspicuous micropyle. *Eimeria canis* of the dog bears a slight resemblance to *E. debliecki* of the pig, especially in the great range of its size, as reported by Wenyon (1923), but it may be distinguished from the latter by the presence of a more or less distinct micropyle and of a large globular body, which may be of the nature of an oöcystic residual body. *Eimeria zürnii* of cattle and *E. tenella* of chickens may also be mistaken for one another by their shape and size and by the absence in both of definite sporocystic residual bodies, but they may be differentiated by the presence in *E. tenella* of a plugged micropyle and of a small globular body inside the oöcyst. In the case of *E. smithi* of cattle and carabaos and *E. debliecki* of swine the similarity is greater. A very close examination of their sporocysts, however, will disclose the fact that those of *E. debliecki* are capped at their rostrated ends, while those of *E. smithi* are not (Plate 1, fig. 7; Plate 2, fig. 5). In this feature alone and in the fact that the oöcyst wall of *E. smithi* is very thin at the micropyle end while that of *E. debliecki* is more or less uniform in thickness throughout, do the two forms constantly differ. In other respects they resemble each other so closely that it is no wonder that several observers have considered them as belonging to a single species. With reference to the isosporan oöcysts, it is possible, as stated above, that they represent two separate species, but only with a full knowledge of their complete life histories could one definitely determine whether they are distinct or not.

TABLE 3.—*Comparison of coccidial oöcysts from different kinds of domesticated animals.*

Species.	Host.	Oöcyst.				Sporocyst.		
		Thickness of oöcyst wall.	Shape and shape index.	Size.	Residual body.	Shape.	Size.	Residual body.
		Microns.		*Microns.*			*Microns.*	
Eimeria zürnii	Cattle; carabao	1.1; uniform	Spherical to ovoidal; 1.10.	$\frac{13.5-20.2}{12.3-18.0}$	None	Lemon-shaped	$\frac{7.8-11.2}{5.1-5.8}$	None.
Eimeria bukidnonensis	Cattle	2; much thinner at micropyle end; micropyle 4 μ across.	Pyriform; 1.37	$\frac{46.8-50.4}{33.3-37.8}$	do	do	$\frac{14.4-21.6}{9.0-11.7}$	Do.
Eimeria smithi	Cattle; carabao	1.3; thinner at micropyle end.	Oval; 1.51	$\frac{28.8-39.6}{19.8-27.0}$	do	do	$\frac{14.4-16.2}{7.2-7.5}$	Present.
Eimeria debliecki	Pig	0.8–1.5; nearly uniform.	Oval; 1.35	$\frac{17.1-32.4}{12.6-23.4}$	do	do	$\frac{9.0-18.0}{5.4-7.2}$	Do.
Eimeria faurei	Sheep; goat	0.8; micropyle covered with a bulging cap.	Oval; 1.37	$\frac{25.2-39.6}{18.0-25.2}$	do	do	$\frac{10.8-14.4}{7.2-9.0}$	Do.
Eimeria canis	Dog	1.2; uniform, with distinct micropyle.	Oval; 1.28	$\frac{27.0-34.2}{21.6-25.2}$	Globular body present.	do	$\frac{14.4-16.2}{7.2-9.0}$	Do.
Eimeria tenella	Chicken	1; uniform; plugged micropyle.	Spherical to oval; 1.11.	$\frac{18.0-21.6}{14.4-21.6}$	Small globular body often present.	do	$\frac{9.0-11.0}{5.5-7.0}$	None.
Isospora rivolta	Dog	0.7; uniform	Oval; 1.23	$\frac{18.0-23.4}{15.7-19.8}$	None	Roundish ellipsoidal.	$\frac{12.6-14.4}{9.0-10.8}$	Present.
Isospora sp	Cat	0.9; uniform	Oval; 1.17	$\frac{21.6-30.6}{19.8-27.0}$	do	do	$\frac{14.4-18.0}{10.8-13.5}$	Do.

SUMMARY

1. Cases of coccidiosis in cow and carabao calves and in pups are reported; also in two adult cats which were apparently only carriers of coccidial parasites, but which came down with acute symptoms of coccidiosis when infected experimentally with surra trypanosomes (*Trypanosoma evansi*).

2. Presuming that young animals derive their infections from their infected mothers and other adult animals that play the rôle of carriers, a survey was made among the different domesticated animals and the oöcysts of the following coccidial parasites were encountered: *Eimeria zürnii, E. smithi,* and a new species, *E. bukidnonensis,* in cattle; *E. zürnii* and *E. smithi* in carabaos; *E. faurei* in sheep and goats; *E. debliecki* in swine; *E. canis* and *Isospora rivolta* in dogs; *Isospora* sp. in cats; *E. tenella* in chickens.

3. These various coccidia appear to be morphologically distinct and the differentiation of their oöcysts is facilitated by means of a table.

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ILLUSTRATIONS

[Unless stated otherwise, the magnification of the figures is × 1120.]

PLATE 1

FIG. 1. *Eimeria zürnii*, young oöcyst; zygote fills entire space within oöcyst wall.
2. *Eimeria zürnii*, oöcyst in which the zygote has contracted preparatory to division.
3. *Eimeria zürnii*, oöcyst with four sporoblasts.
4. *Eimeria zürnii*, mature oöcyst with four sporocysts each of which incloses two sporozoites.
5. *Eimeria smithi*, oöcyst in which the zygote has contracted preparatory to division.
6. *Eimeria smithi*, mature oöcyst with four sporocysts each inclosing two sporozoites.
7. *Eimeria smithi*, enlarged drawing of sporocyst showing details, × 1840.
8. *Eimeria bukidnonensis*, oöcyst in which the zygote has contracted preparatory to division.
9. *Eimeria bukidnonensis*, oöcyst with four sporoblasts.
10. *Eimeria bukidnonensis*, mature oöcyst with four sporocysts each inclosing two sporozoites.

PLATE 2

FIG. 1. *Eimeria faurei*, oöcyst in which the zygote has contracted preparatory to division.
2. *Eimeria faurei*, mature oöcyst with four sporocysts each inclosing two sporozoites.
3. *Eimeria debliecki*, oöcyst in which the zygote has contracted preparatory to division.
4. *Eimeria debliecki*, mature oöcyst with four sporocysts each inclosing two sporozoites.
5. *Eimeria debliecki*, enlarged drawing of sporocyst showing details, × 1840.
6. *Eimeria tenella*, oöcyst in which the zygote has contracted preparatory to division.
7. *Eimeria tenella*, mature oöcyst with four sporocysts each inclosing two sporozoites.
8. *Eimeria canis*, oöcyst in which the zygote has contracted preparatory to division.
9. *Eimeria canis*, mature oöcyst with four sporocysts each inclosing two sporozoites.
10. *Isospora rivolta*, oöcyst in which the zygote has contracted preparatory to division.
11. *Isospora rivolta*, mature oöcyst with two sporocysts each inclosing four sporozoites.

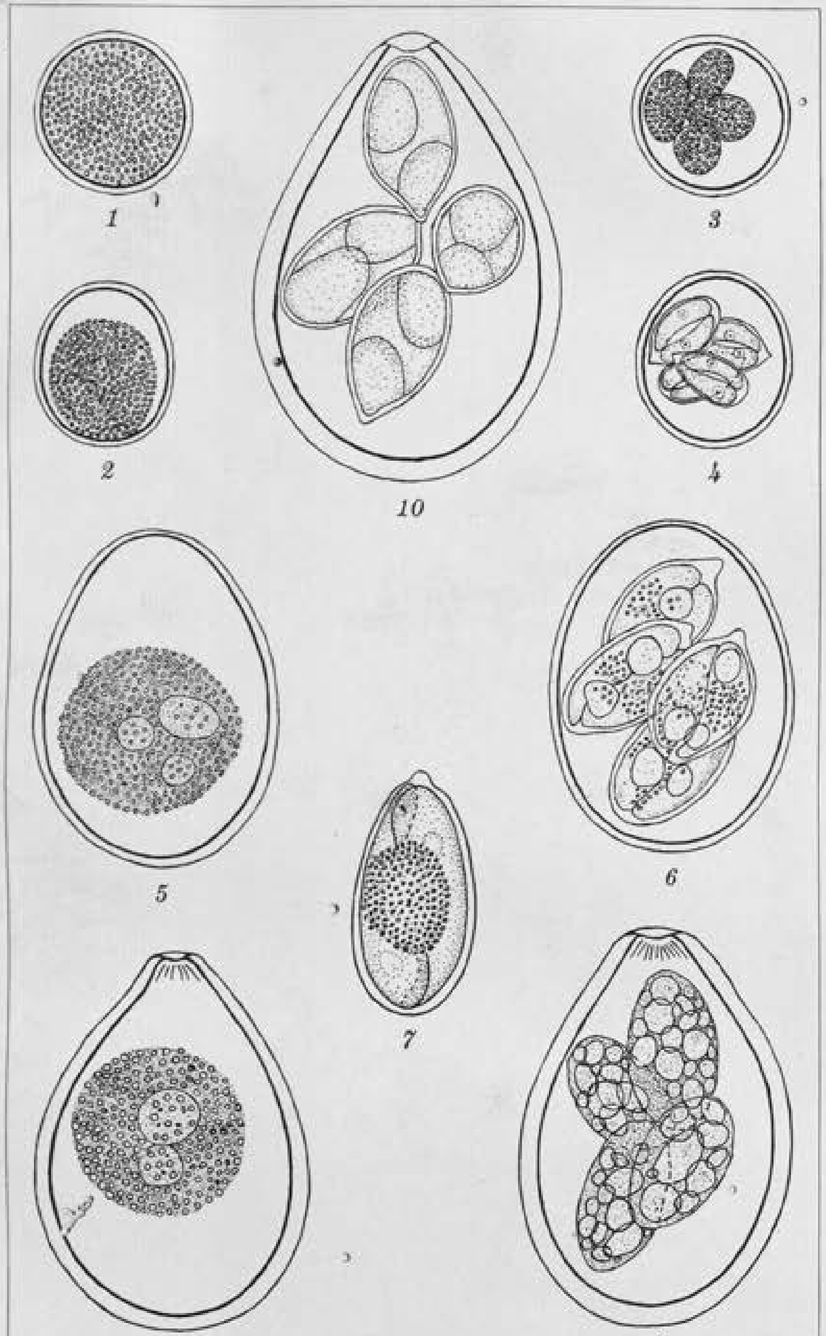

PLATE 1.

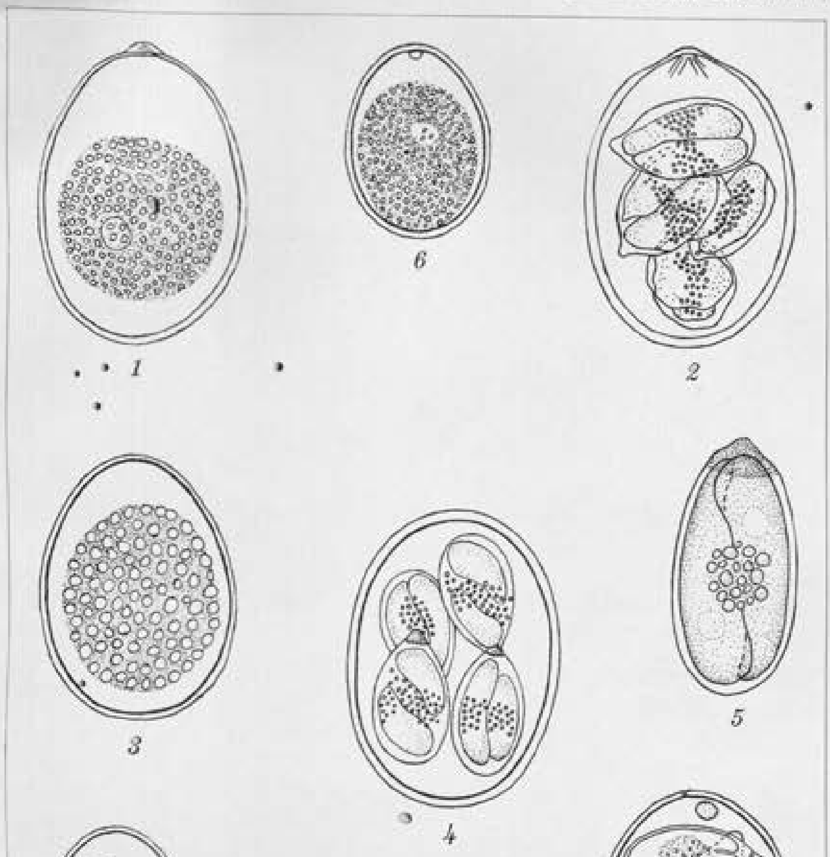

PLATE 2.

TREMATODE PARASITES OF PHILIPPINE VERTEBRATES, II: TWO ECHINOSTOME FLUKES FROM RATS

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TWO PLATES

In 1928, the writer published a descriptive list of trematodes parasitic in Philippine vertebrates. It is the intention to amplify the list from time to time as other related parasites are encountered and identified. The practice adopted of recording the individual worms under their respective hosts will be adhered to. The present paper has to do with two echinostomes found in the small intestine of wild rats, *Mus norvegicus* Erxleben, 1777 (= *M. decumanus* Pallas, 1778). Later, when the number recorded has reached a certain limit, the systematic arrangement of the different forms may be attempted.

The rats from which the parasites were recovered were among those trapped in the City of Manila by representatives of the Philippine Health Service and brought to the Bureau of Science for routine bubonic-plague inspection. Usually many of these rodents are brought in every day, of which three or four are opened for the detection of intestinal and other parasites. Of one hundred nine rats thus far examined, one harbored twenty-one specimens of an echinostome that is believed to be identical with the human intestinal fluke, *Euparyphium ilocanum*=*Echinostoma ilocanum* (Garrison, 1908); another rat yielded over one hundred specimens of an apparently new species of the genus *Euparyphium*.

This report brings the number of recorded species of flukes infesting the brown rat to a total of fourteen. Dollfus (1925), who has reviewed the literature dealing with the parasitic distomes of rats in general, assigns the following to *Mus norvegicus: Echinostoma cinetorchis* Ando and Ozaki, 1923; *E. gotoi* Ando and Ozaki, 1923; *E. macrorchis* Ando and Ozaki, 1923;

E. spiculator (Dujardin, 1843); *Echinoparyphirum japonicum* Ando and Ozaki, 1923; *Heterechinostoma magnovatum* Stunkard and Haviland, 1924; *Clonorchis sinensis* (Cobbold, 1875); *Lepoderma muris* Tanabe, 1922; *Ascocotyle* (*Parascocotyle*) *diminuta* Stunkard and Haviland, 1924; and *Distoma* sp. Podiapolsky, 1924. To these should be added *Ascocotyle arnaldoi* Travassos, 1928, and *Pygidiopsis macrostomum* Travassos, 1928. Among these *Clonorchis sinensis* is a common parasite of human beings in certain regions of China and Japan, while *Echinostoma macrorchis* has been reported once in man by Majima (1927).

EUPARYPHIUM ILOCANUM (Garrison, 1908) Tubangui, 1931. Plate 1, figs. 1, 2, 3, 4.

The adult form of this parasite was first recovered by Garrison (1908) from the stools of Filipino (Ilocano) prisoners in Bilibid Prison, Manila, after the administration of male fern. Garrison believed it represented a new genus and a new species of fluke and called it *Fascioletta ilocana*. Odhner (1911), however, who received four specimens from Garrison, discovered the presence of a spined cephalic collar on one of the specimens and thereby established its position in the old genus *Echinostoma* Rudolphi, 1809. The latest available morphological account of the worm is that by Hilario and Wharton (1917), who not only confirmed Odhner's observation on the presence of a cephalic collar but also contributed other details to its description.

Compared with the specimens of human origin, as described by these various authors, those obtained from the rat appear to differ in the size of the acetabulum, the average length of the œsophagus, the diameter of the cephalic collar, and in other minor features that are liable to occur among members of one species (see Table 1). In their more important characters, they tally with the description of *Echinostoma ilocanum*, except in the nature and extent of the armature of the cuticle and in the number and size of the collar spines. With regard to these structures, however, it should be remembered that the previous descriptions of the parasite were based on specimens obtained after anthelmintic medication. Specimens so obtained must have been in a macerated or partly macerated condition and, very likely, must have lost part or all of the spines on the head collar and on the rest of the body surface. Hilario and Wharton pointed out that these structures are very unstable and easily lost. An examination of the material at hand corroborates this statement, for, of the twenty-one specimens from the rat, three appear to have undergone a certain degree of maceration and are without any scales or spines and the cephalic collar is not evident. These three specimens resemble very closely those that the writer had occasion to collect from the stools of students after the administration of carbon tetrachloride (Tubangui and Francisco, 1925).

This parasite has previously been reported only in natives from Zambales and Ilocos Sur Provinces, Luzon. Its presence in Manila rats is interesting from the standpoint of geographical distribution, for it sustains the view of Hilario and Wharton that the fluke may prove to be found in other places in the Philippine Islands. Whether originally it has had a wider field of distribution or whether it has only been introduced into Manila and other places, is not known. It is certain, however, that the molluscan intermediate host occurs, at least, in Manila, otherwise the parasite could not have found its way into the body of a rat (that is, unless the rat in question was brought to Manila on an interisland steamer from either Zambales or Ilocos Sur). If this be the case, the apparent absence of the worm in other Filipinos may be explained by differences of habit, particularly in the selection and preparation of foods.

In the following description it will be observed that the morphology of the trematode is such that it may be assigned either to the genus *Echinostoma* or to the genus *Eupharyphium*, depending upon what should be considered as the most important distinguishing character of each genus. As defined by Stiles and Hassall (1926), these two genera possess many features in common, differing only in the following respects: In *Echinostoma* the spines of the skin are confined to the ventral surface of the forebody and the uterus is long, with many loops and eggs; in *Eupharyphium* the spines of the skin are found on nearly the entire ventral surface of the body and on the extreme anterior portion of the dorsal surface, and the uterus is short and contains only a few eggs. The fluke in question conforms with the definition of *Echinostoma* in the length of its uterus and in the number of eggs present and with that of *Eupharyphium* in the distribution of its cuticular spines. Conversely, it disagrees with the former genus in the extent of its cuticular spines and with the latter in the length of its uterus.

The length of the uterus, however, does not appear to be a very constant character, at least, in the genus *Echinostoma*, for there are forms like *E. lobulatum* Odhner, 1910 and *E. boleocephalum* (von Linstow, 1873), the uteri of which are short and contain only a few eggs. On the other hand, there are no

TABLE 1.—*Morphology of Euparyphium ilocanum according to different authors.*

Author.	Size.	Cuticle.	Size of oral sucker.	Position of acetabulum.
	mm.		*mm.*	
Garrison, 1908	4.0–6.0 by 0.75–1.35	Smooth	0.13–0.20 by 0.075–0.130.	Between first and second fifths of body length.
Odhner, 1911	4.0–5.0 by 1.00–1.35	Covered with plaquelike scales as far caudad as posterior testis.	0.18 (diameter)	At about 0.7 mm from anterior end.
Hilario and Wharton, 1917	4.03–7.82 by 0.98–1.60	In some specimens anterior part of body covered with very small spines; spines seem very unstable and easily lost.	0.120–0.200 (diameter)	Middle of anterior third of body length.
Tubangui, the present paper	5.57–8.02 by 1.33–1.58	Covered, ventrally up to second testis or beyond and dorsally up to acetabulum, with flat scales.	0.19–0.24 (diameter)	Do.

Author.	Size of acetabulum.	Diameter of head collar.	Number of collar spines.	Size of pharynx.	Length of œsophagus.
	mm.	*mm.*		*mm.*	*mm.*
Garrison, 1908	0.48–0.52 (diameter)			0.15–0.19 (diameter)	0.05–0.10.
Odhner, 1911	0.40–0.46 (diameter)	0.30–0.33	49	0.17 by 0.11	Short (0.16 mm, according to Odhner's illustration).
Hilario and Wharton, 1917	0.53 (average diameter)		39	0.160 (average diameter)	0.05–0.12.
Tubangui, the present paper	0.60–0.69 by 0.64–0.74	0.34–0.46	51	0.19–0.20 by 0.15–0.17	0.10–0.20.

TABLE 1.—*Morphology of Euparyphium ilocanum according to different authors*—Continued.

Author.	Shape and position of ovary.	Shape of testes.	Anterior extent of vitellaris.	Size of cirrus sac.	Size of eggs.
				mm.	*Microns.*
Garrison, 1908	Globular; at center of body length, slightly to right of median line.	More or less distinctly divided by transverse circular constriction into anterior and posterior lobes or 4- to 5-lobed.	Slightly behind junction of anterior and middle thirds of body length.	0.560–0.608 by 0.240–0.280	88.8–114.7 by 53.5–81.9.
Odhner, 1911	Transversely compressed, median, in front of testis.	Deeply lobed	Short distance behind acetabulum.		92–114 by 53–82.
Hilario and Wharton 1917.	Globular; a little to right of median line, at about middle of body length.	Oval, but generally elongated and distinctly divided into anterior and posterior lobes by transverse constriction.	Midway between posterior border of acetabulum and anterior border of ovary.	Twice as long as wide	88.8–111.0 by 58.6–74.4
Tubangui, the present paper.	Globular, or slightly compressed transversely, median, preëquatorial, at about middle of second fourth of body length.	Elongate and divided into anterior and posterior lobes by transverse constriction or shorter and deeply indented into 3 or 4 lobes.	do	0.51–0.65 by 0.26–0.34	85.5–101.5 by 54.0–64.2

available indications as to the variability of the armature of the body surface among members of the two genera. It would appear, therefore, that the distribution of the cuticular spines constitutes a better criterion in differentiating between these two groups of echinostomes. For this reason the parasite from the rat has been assigned to the genus *Euparyphium*.

DESCRIPTION

Body moderately large, elongate, grayish and opaque in appearance in the preserved condition, except at anterior end where it is whitish and more transparent; measures from 5.57 to 8.02 by 1.33 to 1.58 millimeters, maximum breadth at or near equator of body; anterior extremity attenuate, posterior end rounded. Lateral sides of body from anterior end to acetabulum rolled ventrally. Cuticle armed with flat scalelike structures (Plate 1, fig. 3), which are distributed ventrally from anterior end to second testis or slightly beyond that level, and dorsally from anterior end to level of anterior border of acetabulum; scales 13.5 to 24.7 by 13.5 to 18.0 microns in size, those at anterior end being smaller. Suckers close together; oral sucker small, subterminal, 0.19 to 0.24 millimeter in transverse diameter; acetabulum large, cup-shaped, at middle of anterior third of body length, 0.60 to 0.69 by 0.64 to 0.74 millimeter in size. Oral sucker surrounded dorsally and laterally by a collar (Plate 1, fig. 2) bearing fifty-one spines arranged in two alternating rows; collar 0.38 to 0.46 millimeter in diameter, reniform, its two rounded ventral angles united ventrally by a narrow ridge. Collar spines may be grouped as follows: Six ventral corner spines on each side of collar, the smallest of which measures 36.0 by 11.2 microns, the widest 42.7 by 15.7 microns, and the longest 45.0 by 11.2 microns; fourteen lateral spines on each side, arranged in pairs and eleven dorsal spines; lateral and dorsal spines 31.5 to 45.0 by 11.2 to 13.5 microns in size.[1]

Mouth terminal to subterminal, followed in some specimens by a very short prepharynx, 0.03 to 0.05 millimeter in length; pharynx 0.19 to 0.20 by 0.15 to 0.17 millimeter in size; œsophagus 0.10 to 0.20 millimeter long, bifurcating immediately in front of level of genital pore, midway between pharynx and, acetabulum or slightly anterior of that level; intestinal cæca reach posteriorly to from 0.24 to 0.43 millimeter from posterior end of body.

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[1] Observations on arrangement and measurement of body scales and collar spines in this and the next species were made not on stained and dehydrated material but on compressed alcoholic specimens cleared in glycerin. It is rather difficult to measure and to count accurately the collar spines on stained specimens mounted in balsam.

Testes tandem, postequatorial, at third fourth of body length, either elongate and each divided into anterior and posterior lobes by transverse constriction or shorter and distinctly 3- or 4-lobed (Plate 1, fig. 4). Cirrus sac large, 0.51 to 0.65 by 0.26 to 0.34 millimeter in size, reaching to but not extending posteriorly beyond equator of acetabulum; incloses prominent seminal vesicle, well-developed pars prostatica, and protrusible cirrus. Common genital opening preacetabular, behind œsophageal bifurcation, to one side of median line.

Ovary globular or slightly compressed transversely, median, preëquatorial, usually behind middle of second fourth of body length, 0.31 to 0.43 by 0.34 to 0.48 millimeter in size; shell gland large, between ovary and anterior testis; receptaculum seminis absent, Laurer's canal present; uterus well-developed, occupying space bounded by ovary, acetabulum, and intestinal cæca. Vitellaria in moderately large follicles, commencing anteriorly on both sides at level about midway between posterior border of acetabulum and anterior border of ovary; anteriorly they are extracæcal, but behind second testis the follicles from the two sides unite and occupy most of posterior body region; transverse vitelline ducts and vitelline reservoir dorsal of shell gland, directly in front of anterior testis. Eggs numerous, operculated, light brown or yellowish, 85.5 to 101.5 by 54.0 to 65.2 microns in size.

Excretory system typical of echinostomes in general; excretory bladder long, with several small side branches, dividing into two principal branches behind second testis; excretory pore at extreme posterior end of body.

In view of the above anatomical findings, *Euparyphium ilocanum* should have the following—

Specific diagnosis.—Euparyphium: Body moderately large, elongate, 4.00 to 8.02 by 0.75 to 1.60 millimeters in size. Cuticle armed with flat scales, ventrally from anterior end to level of second testis or slightly beyond and dorsally from anterior end to level of acetabulum. Spines on cephalic collar fifty-one, grouped into six ventral corner and fourteen lateral spines on each side and eleven dorsal spines. Prepharynx very short;

œsophagus short to moderately long. Testes either elongate and divided by transverse constriction into anterior and posterior lobes or shorter and distinctly 3- to 4-lobed; cirrus sac large, reaching to but not beyond equator of acetabulum. Ovary globular or transversely oval; uterus well developed; eggs 85.5 to 114.7 by 53.5 to 82.0 microns in size.

Hosts.—Man, rat (*Mus norvegicus*).

Location.—Small intestine.

Localities.—Zambales, Ilocos Sur, Manila (? Ilocos Norte), Luzon.

EUPARYPHIUM GUERREROI sp. nov. Plate 2, figs. 1, 2, 3, 4.

This fluke differs from the echinostomes that have so far been reported from rats by the number of its collar spines, of which there are fifty-five. I take the pleasure of naming it in honor of Dr. Luis Guerrero, who, some years ago during a conversation, mentioned having encountered an echinostome in the intestine of a rat and who, therefore, was partly responsible in directing my attention to a study of the helminths infesting rats.

DESCRIPTION

Body slender, elongate, measuring 2.92 to 4.03 by 0.37 to 0.50 millimeters; maximum breadth across acetabulum or anywhere between that organ and anterior testis. Cuticle armed with flat scales, dorsally from anterior end to level of acetabulum and ventrally from anterior end to posterior testis or slightly beyond that level; scales (Plate 2, fig. 3) 6.0 to 15.0 by 5.5 to 9.4 microns, anterior ones being smaller. Oral sucker weak, subterminal, 0.10 to 0.12 millimeter in transverse diameter; acetabulum more powerful, at middle of anterior third of body length, 0.27 to 0.36 by 0.31 to 0.34 millimeter in size. Oral sucker surrounded dorsally and laterally by a collar bearing fifty-five spines arranged in two alternating rows; collar (Plate 2, fig. 2) 0.22 to 0.26 millimeter in diameter, reniform, its two ventral angles united by a narrow ridge. Collar spines may be grouped as follows: Five ventral corner spines on each side of cephalic collar, 24.7 to 31.5 by 9.0 to 11.9 microns; fifteen lateral spines on each side, 27.0 to 29.2 by 9.0 microns; and fifteen dorsal spines, 11.2 to 13.5 by 6.7 to 9.0 microns in size.

Mouth subterminal to terminal, succeeded by prepharynx 0.03 to 0.07 millimeter long; pharynx 0.10 to 0.11 by 0.07 to 0.08 millimeter in size; œsophagus 0.08 to 0.15 millimeter long, bifurcating in front of level of genital pore; intestinal cæca long, narrow in diameter, reaching to from 0.21 to 0.24 millimeter from posterior end of body.

Testes (Plate 2, fig. 4) tandem, postequatorial, at third fourth of body length, oval or sausage-shaped, often transversely constricted into anterior and posterior lobes; anterior testis usually smaller, at least shorter, 0.19 to 0.36 by 0.15 to 0.22 millimeter; posterior testis 0.27 to 0.39 by 0.12 to 0.20 millimeter in size. Cirrus pouch oval, 0.17 to 0.27 by 0.10 to 0.13 millimeter in size, immediately behind œsophageal bifurcation, not reaching posteriorly beyond equator of acetabulum; incloses large seminal vesicle, moderately developed pars prostatica, and protrusible cirrus; cirrus aspinose. Common genital opening preacetabular, behind œsophageal bifurcation, to one side of median line.

Ovary globular or slightly compressed; 0.10 to 0.15 by 0.07 to 0.13 millimeter in size, directly preëquatorial, pretesticular; shell gland prominent, filling most of the space between ovary and anterior testis; receptaculum seminis absent, Laurer's canal present; uterus short, with few coils, between ovary and acetabulum. Vitellaria in small or moderately large follicles, commencing anteriorly at middle of second fourth of body length, those on left side usually commencing at a more posterior level; behind second testis follicles from two sides unite and extend to posterior end of body; transverse vitelline ducts and vitelline reservoir dorsal of shell gland and immediately in front of second testis. Eggs few, operculated, thin shelled, light brown or yellowish, 78.7 to 85.5 by 54.0 to 60.7 microns in size.

Excretory system of usual echinostome type; excretory bladder long, tubular, dividing into two branches behind second testis; excretory pore at extreme posterior end of body.

Specific diagnosis.—Euparyphium: Body small, slender, 2.92 to 4.03 by 0.37 to 0.50 millimeters in size. Cuticle armed with flat scales, 6.0 to 15.0 by 5.5 to 9.4 microns in size. Head collar 0.22 to 0.26 millimeter in diameter, with fifty-five spines arranged in two alternating rows and grouped as follows: Five ventral corner and fifteen lateral on each side of collar and fifteen dorsal spines. Prepharynx and œsophagus 0.03 to 0.07 and 0.08 to 0.15 millimeter long, respectively. Testes postequatorial, unequal, oval or sausage-shaped, often constricted in middle into anterior and posterior lobes. Cirrus sac 0.17 to 0.27 by 0.10 to 0.13 millimeter in size, not reaching posteriorly beyond equator of acetabulum. Pars prostatica moderately developed. Cirrus aspinose. Ovary globular or slightly compressed, median, directly preëquatorial. Vitellaria extend from middle of second fourth of body length to posterior end of body. Eggs 78.7 to 85.5 by 54.0 to 60.7 microns in size.

Host.—*Mus norvegicus* Erxleben, 1777.

Location.—Small intestine.

Locality.—Manila, Luzon, Philippine Islands.

Type specimens.—Philippine Bureau of Science parasitological collections, No. 50.

SUMMARY AND CONCLUSIONS

1. In the examination of rats (*Mus norvegicus*) for intestinal and other parasites two echinostome flukes were obtained; namely, *Euparyphium ilocanum, Echinostoma ilocanum* (Garrison, 1908) and *Euparyphium guerreroi* sp. nov.

2. *Euparyphium ilocanum* was first recorded in native Filipinos from Ilocos Sur, Luzon, and subsequently in natives of the neighboring province of Zambales.

3. Its presence in a Manila rat may mean that this human parasite has a wider field of distribution than has formerly been supposed and that rats are a factor in its dissemination.

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ILLUSTRATIONS

ABBREVIATIONS

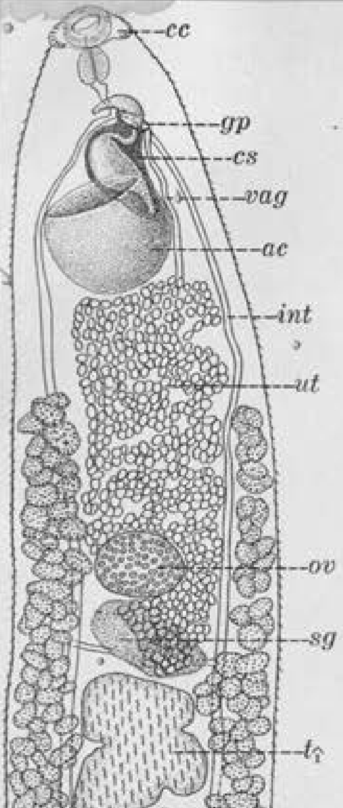
ac, acetabulum.
cc, cephalic collar.
cs, cirrus sac.
ep, excretory pore.
gp, genital pore.
int, intestine.
lc, Laurer's canal.
oes, œsophagus.
os, oral sucker.
ov, ovary.
ph, pharynx.
pph, prepharynx.
sg, shell gland.
sp, spines.
t, testis.
ut, uterus.
vag, vagina.
vg, vitelline glands.

Plate 1. Euparyphium ilocanum (Garrison, 1908)

Fig. 1. Toto mount, ventral view.
2. Anterior end of body, ventral view, showing arrangement of spines on head collar.
3. Body scales.
4. Variations in the shape of the testes.

Plate 2. Euparyphium guerreroi sp. nov.

Fig. 1. Toto mount, ventral view.
2. Anterior end of body, ventral view, showing arrangement of spines on head collar.
3. Body scales.
4. Variations in the shape of the testes.



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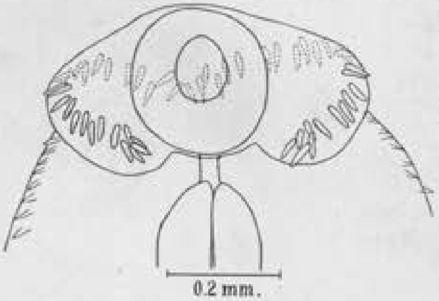

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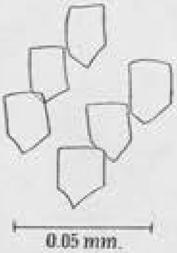

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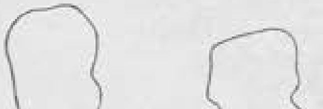

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PLATE 1.

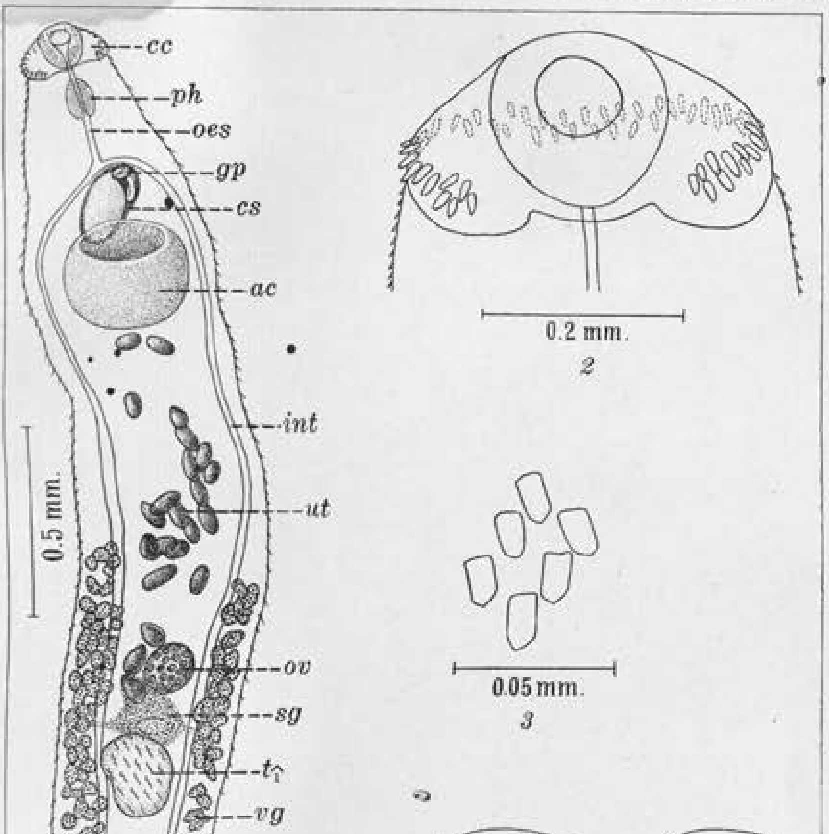
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PLATE 2.

TWO NEW MADREPORARIAN CORALS FROM CALIFORNIA

By LEOPOLDO A. FAUSTINO

Chief Geologist, Bureau of Science, Manila

ONE PLATE

Students of madreporarian corals do not usually regard the west coast of America as particularly productive of corals, although a number of species, both Recent and fossil, have already been reported from the region. As compared with the other coral areas of the world, even in that portion of the coast which is in the tropical zone, namely, the western shores of Central America and Mexico, the reef corals are weakly developed. Specimens of the following two new species of corals were handed me for identification and description in 1924 by Dr. James Perrin Smith when I was at Leland Stanford Junior University, California. The figure of *Dendrophyllia oldroydi* sp. nov. has already appeared.[1]

Family FUNGIIDÆ Dana

Genus SIDERASTREA de Blainville

SIDERASTREA RADCLIFFI sp. nov. Plate 1, fig. 1.

The following is the description of the type, which is a single specimen preserved in the Stanford University palæontological collection.

Corallum incrusting almost the whole surface of a *Turritella* shell. It is not outside the range of probability that the fully grown corallum may be massive or ramose.

Calices irregular in form, subpolygonal and more or less circular. Diameter from 3 to 5 millimeters, when not deformed or prismatic on account of pressure from neighboring calices; depth about 1 millimeter. Synapticulæ show in several places.

Septa in four cycles. The primaries are rather thick and pronounced and reach the calicular center. These are easily distinguished. The secondaries also reach the calicular center, but the tertiaries do not and the quaternaries fuse to the sides of the lower orders. Margins not exsert; within the shallow calices straight or slightly concave upward, within the deep calices descending somewhat abruptly to the calicular center. The septa are trabecular, interrupted, and perforate.

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[1] Stanford University Publications, Geological Sciences, 1: No. 1, pl. 49, fig. 7.

Columella small and slightly developed, sometimes formed by the junction of the ends of the principal septa; occasionally two septa meet in the center and extending across the calice divide it into two, more or less subequal, compartments.

Locality and geologic occurrence.—Camulos Quadrangle, ¾ mile N. E. of Camp near Simi Peak, Ventura County, California, collected by T. D. Radcliff. Martinez formation; lower Eocene.

Remarks.—I have hesitated referring this coral to *Siderastrea* on account of the usually distinct calicular margins, which are not typical of *Siderastrea.* Doctor Vaughan suggested comparison with *Oulastrea* to which it is very closely allied. The genus *Oulastrea,* however, has been reported only as living from the Indian Ocean and it is unlikely that it would suddenly occur in the California Eocene. On the other hand, the genus *Siderastrea* is already represented on the coast by three other species; namely, *S. mendenhalli* Vaughan, *S. californica* Vaughan, and *S. vancouverensis* Vaughan. The Martinez horizon of California Tertiary has yielded but few corals and these are all simple forms. The species described above belongs to the colonial astreiform group, and is the first record of this group to have come from the Eocene formation of the West Coast.

Family EUPSAMMIDÆ Milne Edwards and Haime

Genus DENDROPHYLLIA de Blainville

DENDROPHYLLIA OLDROYDI sp. nov. Plate 1, fig. 2.

Colony high and arborescently branched. Two specimens are in the Stanford University collection; one is 30 centimeters high and 38 centimeters across in one direction, the other is 24 centimeters high with branches not so numerous and with a thick base. The branching is irregular and apparently takes place wherever there is opportunity. Budding takes place at the base of the branches and at the sides. The main stem of the first specimen, which is regarded as the type, is 1 centimeter, and the branches are about the same size. The base of the second specimen is 3 centimeters and the main branches 2 centimeters.

The corallites are subcircular, the largest are 1 centimeter in diameter, and project as much as 7 millimeters above the base. Wall perforate, covered externally with fine subequal costal striations, somewhat scabrous, corresponding to all septa. Corallites not very deep, with a jagged edge.

Septa in four complete cycles, often with narrow rudimentary septa corresponding to the fifth cycle. The form and arrangement of the septa are clearly shown in the figure.

Columella well developed, rather prominent, sometimes occupying about a third of the breadth of the corallite, composed of convoluted and contorted porous plates.

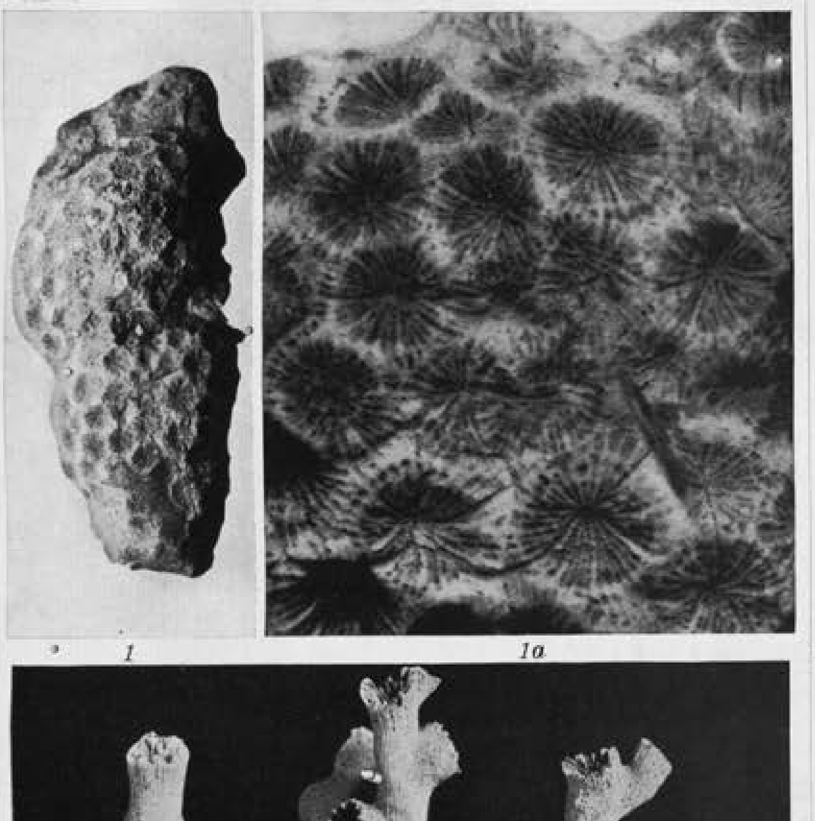
Localities.—Sunken Valley, between San Pedro and Redonda, California, 200 fathoms; deep water off San Diego, California.

ILLUSTRATION

PLATE 1

FIG. 1. *Siderastrea radcliffi* sp. nov., general view of the corallum, natural size; 1*a*, calices of the same, × 4.

2. *Dendrophyllia oldroydi* sp. nov., branch of the type, natural size.



1 1a

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PLATE 1.

CORAL REEFS OF THE PHILIPPINE ISLANDS

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Chief Geologist, Division of Geology and Mines
Bureau of Science, Manila

THREE PLATES AND THREE TEXT FIGURES

INTRODUCTION

The purpose of the present paper is to present a preliminary report on the coral reefs of the Philippine Islands. It is the first of a series of reports to be made from time to time by the committee on coral reefs of the Philippine Islands, formed at the specific request of Dr. T. Wayland Vaughan in his capacity as chairman of the International Committee of the Pacific Science Congress on the studies of coral reefs and coral-reef phenomena.

The following program of work is proposed by Doctor Vaughan in his circular letter dated July 15, 1927:

I. Associated organisms of the reefs, their ecology, life histories, growth rates, relative importance as constructional agents. Data on temperature, salinity, pH, quantity of plankton, and other data of ecological significance.
II. The marine bottom deposits associated with the reefs. The nature and quantity of the organic matter in the bottom muds. Bacteria associated with the bottom muds specially in lagoon areas.
III. Stratigraphy of the reefs with particular reference to the foundation on which the reefs have been built.
IV. Physiography of the sea-bottom, the shore-line, and the zone interior to the shore-line in each coral reef area.
V. Geologic history of each area in which reefs occur and the relations of the reefs to that history.

LITERATURE AND ACKNOWLEDGMENT

Corals and coral reefs of the Philippine Islands have received the attention of naturalists and scientific men from the time of Darwin to the present day. Darwin's map giving the distribution of the different kinds of coral reefs shows fringing reefs in the Babuyan Islands north of Luzon, on the west coast of

Luzon, southeastern Luzon and northern Samar, southern Masbate, around Bohol, southern and southeastern Mindanao, and around the Sulu Archipelago. Apo Reef, southeast of Mindoro, is marked as an atoll. Dana in his Corals and Coral Islands regarded Sulu Sea as a coral-reef region of some extent, but remarked that for the rest of the Philippine Archipelago coral reefs were little developed. Semper's work on the coral reefs of the Philippines and the Pelew Islands led him to doubt the subsidence theory of Darwin and gave rise to another theory which regards solvent action as the main cause of the formation of barrier reefs. Trinidad Valley near Baguio, Mountain Province, was considered by him an excellent example of an elevated atoll and this conclusion was generally accepted until studies by Dickerson and Smith revealed the fact that it was not an atoll but merely the result of a peculiar erosional development. Arana's Derrotero del Archipiélago Filipino, which is the official Spanish "sailing directions" for the Philippines, notes the presence of the numerous coral reefs. Horsburgh's directions for sailing to and from the East Indies likewise show coral reefs in Philippine waters. Studies of Philippine coral reefs by Davis were embodied in three publications: Fringing Reefs of the Philippine Islands, Subsidence of Reef-encircled Islands, and the Coral Reef Problem. The United States Coast Pilot, Philippine Islands, parts 1 and 2, and the excellent charts of the Philippine Islands published by the United States Coast and Geodetic Survey show the occurrence and the distribution of the coral reefs. The writer's Recent Madreporaria of the Philippine Islands gives an account of the living corals of the Philippine waters. Coral reefs and reef corals of the Philippines have received more or less attention in the different publications touching on the geology and geography of the Philippines.

It is desired to acknowledge with thanks the earnest coöperation of the members of the Philippine Committee on Coral Reefs, more particularly Lieutenant Commander Colbert and the members of the United States Coast and Geodetic Survey stationed in Philippine waters, upon whom I must depend for data not available elsewhere.

LIVING CORAL REEFS OF THE PHILIPPINE ISLANDS

The majority of the coral reefs of the Philippine Islands belong to the class known as fringing reefs, and they rarely exceed 3 miles in width and generally extend less than 1 mile from the shore. Barrier reefs occur rather sparingly and, with the exception of the Bohol Barrier Reef on the northwest coast of Bohol and the Tawitawi Barrier Reef in the Sulu Archipelago, are of small dimensions; the channel between the reef and the shore is generally about 100 to 300 yards wide. Atolls are not rare in the Sulu Archipelago, although it is admitted that they are small and only an extensive cruise in the Sulu Sea or a close examination of large scale charts reveals the presence of a great number of them.

The living coral reefs are less developed in the northern than in the central and the southern Philippines. The islands of the Batan group, the most northern of the Philippine Islands, are surrounded by narrow, disconnected fringes of coral reef. In the Babuyan group, Calayan Island is also fringed by a narrow coral reef. A coral shoal known as Herminia Shoal lies about 2.5 miles off the southwest part of Dalupiri Island, while Camiguin is fringed by a narrow steep-to coral reef. The north coast of Luzon is apparently devoid of coral reefs, as only a narrow coral reef fringes Dialao Point on the northwest coast. The shores of northern Luzon descend precipitously into the sea, and the large Cagayan River discharges its sediments there. The eastern coast of Luzon is imperfectly known.

In the central and the southern Philippines on the other hand the coral reefs are more profusely developed. There are many large and small islands scattered after the manner of most of the archipelagoes in the western Pacific, all more or less embayed. The entire coast line of the Philippine group south of latitude 15° north, with few exceptions, is fronted with coral reefs of varying stages of development. Some are narrow disconnected fringes with or without any living corals; some have parts only slightly submerged and covered with mangroves; others make off from the mainland in a direction tangent to the coast line. The fringing reefs are generally well developed on the headlands and promontories and in small bays or coves or along a straight coast. At the mouths of the larger rivers they are generally dead or covered with sand and with an opening or break across the reef.

The best occurrence of a barrier reef in the Philippines is along the north coast of Bohol. The large Danajon Bank extends northward from Bohol about 40 miles east and west and from 5 to 14 miles north and south. The outer edge of the bank is marked by a chain of steep-to coral reefs, 0.5 to 2 miles wide, with a number of breaks. Depths in the lagoon between the reefs and the mainland are generally from 20 to 25 fathoms. The Northwest Bank, also studded with islets and reefs, is the southwest prolongation of Danajon Bank.

The best development of atolls is found in the Sulu Sea and vicinity. Apo Reef, noted by Darwin, lies southwest of Mindoro and is about 10 miles long in a north-northwest direction and about 6 miles wide. The reef is surrounded by deep water. Pearl Bank, in the Sulu Archipelago, is about 15 miles long northeast and southwest and about 9 miles wide. In the middle is a coral-reef patch, more or less circular in form, about 7 miles in diameter, and bare in patches during low water. Two islets, Taja and Zau, lie on opposite sides of the circular reef. The lagoon in the center is less than 1 fathom deep. Tumindao Atoll is elongated north and south with Tumindao Island forming the eastern rim. It has two lagoons, the North Lagoon and the South Lagoon. The North Lagoon is 8 to 10 fathoms deep with two outlets.

Lying off the southern coast of Zamboanga Peninsula is Santa Cruz Bank, a coral atoll about 2 miles wide and extending 8 miles in a direction parallel to the coast. The channel in the middle of the atoll has a depth of not less than 8 fathoms. The outline of the atoll is marked by shoal patches having depths of 1 foot to 4 fathoms.

In addition to the three main types of coral reefs noted in the preceding paragraphs a fourth type is encountered to which the name "shoal reef" is applied. A shoal reef is here defined as a patch of coral reef below sea level which occurs at a variable distance from the shore and which is surrounded by deep water, say 20 to 40 fathoms and even a greater depth, and which apparently has no direct connection with the fringing reef that borders the land and does not form part of the barrier reef in the locality. The term shoal reef was cited by Molengraaff[1] as having been used by Niermeyer to indicate fringing reefs of broad development on a shelf. The shoal reefs of the Philippines lie in the main on the submerged banks or shelves. Among these may be mentioned the following: Ranger Reef lying a few miles east-southeast of Simara Island, Romblon Province, about 2 fathoms deep and surrounded by deep water. Circe Bank, a shoal reef with a least depth of 3.5 fathoms lies about 10 miles east-northeast of Jintotolo Island, Masbate Prov-

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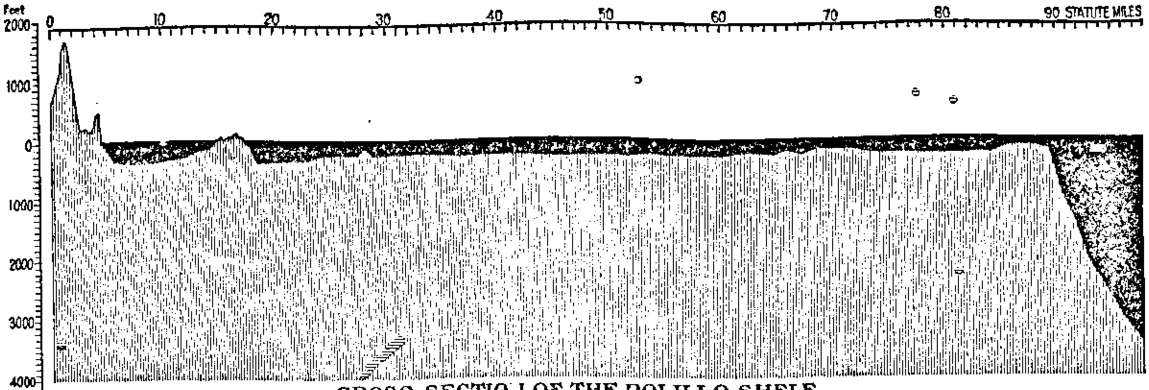
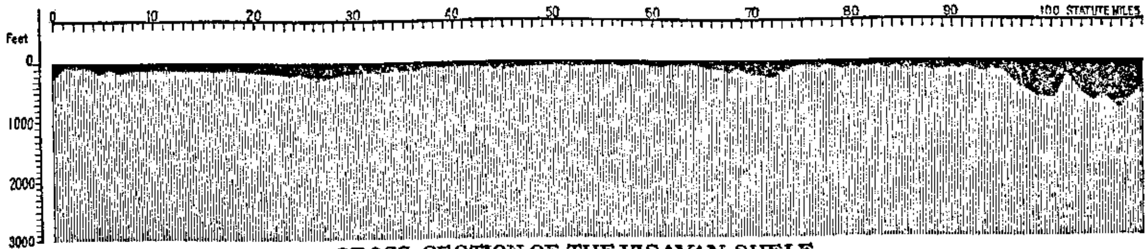
[1] The Coral Reefs in the East Indian Archipelago, their Distribution and Mode of Development, Fourth Pacific Science Congress **1** (1929).



CROSS SECTION OF THE POLILLO SHELF
from Tayabas, Luzon Island, Northeast to Pacific Ocean
Along Line K-L



CROSS SECTION OF THE VISAYAN SHELF
At Latitude N. 11° 42′
Along Line G-H

FIG. 1. Cross section of the Polillo shelf and the Visayan shelf.

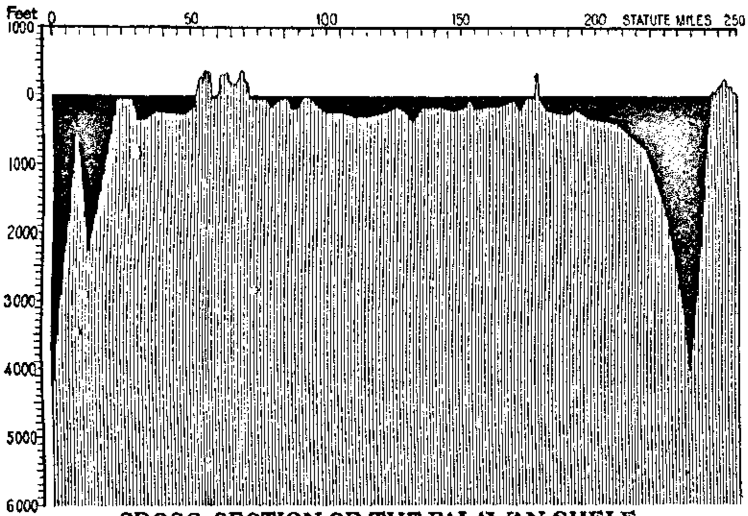
ince. A small coral reef called Sardine Reef, with a least depth of 2.25 fathoms and surrounded by deep water, lies about 1.75 miles west of Ilin Island and 2.5 miles north of Ambulong Island, Mindoro Province. A shoal reef known as Queen of the Sea Bank covers a considerable area in latitude 10° 24.3′ north, longitude 120° 28.5′ east, and has a least depth of 3.5 fathoms. The east coast of Palawan apparently has many coral reefs lying from 10 to 20 miles off the coast. Circe Shoal is a coral bank lying in latitude 8° 26′ north, longitude 117° 56′ east. Balabac Strait, between the China and Sulu Seas, is for the greater part occupied by numerous coral shoals and banks. Fronting the west coast of Palawan is a bank with numerous coral patches and shoals. Among these may be mentioned South Regent Shoal, North Regent Shoal, Antelope Shoal, Scalesby Castle Shoal lying 1.5 miles within the edge of the Palawan shelf, and coral shoals and patches without number from this coral shoal to the parallel of 9° 35′ north, all lying on the edge of the shelf. Crescent Reef lies in latitude 10° 40′ north, longitude 118° 42′ east, within 1.5 miles of the edge of the Palawan shelf and about 22 miles from the nearest land. It is a narrow strip 0.75 mile in length running east-northeast and west-southwest.

SUBMERGED BANKS AND SHELVES

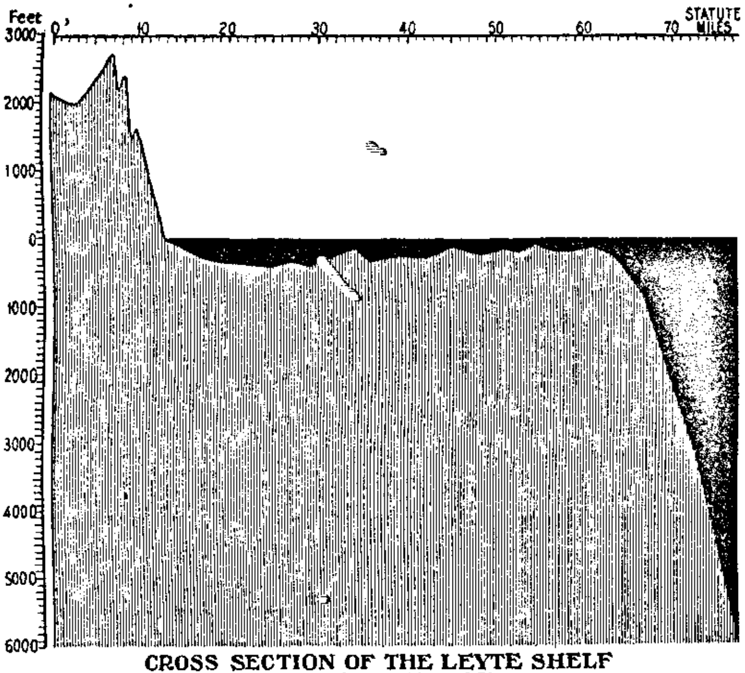
Numerous submerged banks and shelves are found throughout the Philippine Islands. Some of these are of comparatively great dimensions, and are apparently of origin independent of corals. The majority of these, as may be seen by reference to the relief map of the Philippine Islands (Plate 1), are submarine plains lying not more than 50 fathoms below sea level. Among these submerged banks and shelves may be mentioned the Polillo shelf, east of Luzon; the Visayan shelf, between Panay and Masbate; the Palawan shelf, surrounding Palawan Island; the Leyte-Samar shelf, east of Leyte; and the Sulu shelf, west of Mindanao.

The Polillo shelf, on the east of Luzon bordering the Pacific deep, is approximately 150 miles long, along an east-and-west line, and about 50 miles wide. This submarine plain extends from Polillo Island to Catanduanes Island and averages about 25 fathoms below sea level. Numerous islets and coral shoals are scattered on this shelf.

The Visayan shelf is a low-lying submarine platform, located between Panay, Negros, and Masbate Islands and almost in-



CROSS SECTION OF THE PALAWAN SHELF
At Latitude N. 10°55'
Along Line C-D



CROSS SECTION OF THE LEYTE SHELF
At Latitude N. 10°35'
Along Line E-F

FIG. 2. Cross section of the Palawan shelf and the Leyte shelf.

closed by them. The greatest depths on the shelf are on the eastern side and average 25 fathoms, but the greater portion of the shelf is only about 10 to 15 fathoms below sea level.

The Leyte-Samar shelf is located between Samar and Mindanao and is the submarine connection between the two islands. This submarine shelf is long and narrow with a deeper portion in the middle western part. The bank has an average depth of 22 fathoms. Its eastern edge descends precipitously into the Philippine deep.

The Sulu shelf is the submarine prolongation of Mindanao, which connects it with Borneo. This submarine platform maintains an average width of about 50 miles but has a deep channel in the middle. There are depths between 40 to 50 fathoms, but the greater portion of the area averages about 18 fathoms. The islands of the Sulu Archipelago, in part volcanic, in part composed of coral limestone, stand on this bank.

Palawan is a long island extending 250 miles southwest to Borneo and is bordered on all sides by a submarine shelf, which is widest on the north and northeast. The outer edge of the shelf on the west coast runs almost parallel with the shore line, maintaining an average width of 20 miles, and while there are depths of 40 and 50 fathoms the majority of the soundings average about 10 fathoms. The eastern shelf is not so wide, but the platform widens to the north and east. The Calamian Group and the Cuyo Islands stand on the northeastern prolongation of the shelf.

The origin of these submerged banks and shelves presents a very interesting study. Davis pointed out that "the submarine platforms that border some of the islands are best explained as submerged and more or less aggraded reef plains." At present it is believed that these submerged shelves are of Pleistocene origin and that they are due in the main to the shift of ocean level in the tropical seas during Pleistocene time on account of glaciation and deglaciation. The change in level has been estimated by Daly[2] as between 60 and 70 meters (33 to 38 fathoms). Vaughan[3] pointed out that the period of maximum glaciation was probably not of long duration and the greatest effect of submarine terracing would be expected in somewhat shallower depths, probably between 37 and 55 meters (20 and 30 fathoms). The Pleistocene corals are not so wide-

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[2] Proc. Am. Acad. Arts and Sci. 51: 174.

[3] Bull. U. S. Nat. Mus. 103 (1919) 253.

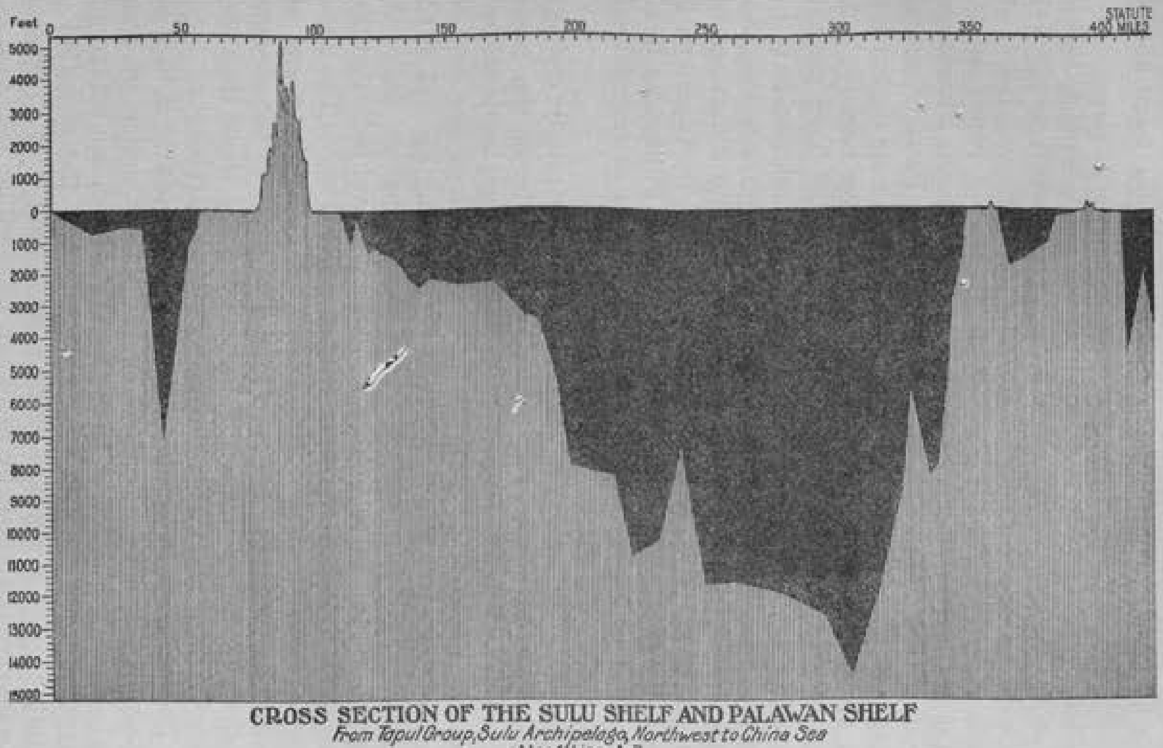

FIG. 3. Cross section of the Sulu shelf and the Palawan shelf.

spread as are those formed in the earlier periods, owing in a large measure to the cold climate that prevailed during Pleistocene time, and the consequent reduction in the rate of formation of the coral reefs. The protection coral reefs afforded the shores being thus lessened, the waves of the sea were able to cut fairly extensive submarine plains.

Reference to the relief map of the Philippine Islands (Plate 1) will show that the submerged banks and shelves correspond in general to the white areas included between the 100-meter isobath and the shore line. Umbgrove in his paper on the amount of the maximum lowering of sea level in the Pleistocene, presented at one of the sessions of the Fourth Pacific Congress in Java (1929), came to the conclusion that the maximum lowering of the sea level in the Pleistocene for the region of the Sunda shelf in the East Indian Archipelago must have amounted to approximately 100 meters. Most of the submarine plains found in the different parts of the Archipelago are less than 100 meters (54 fathoms) below sea level. The difference between this figure and the present depths may be explained by successive uplifts and elevation of the entire Philippine block.

The criteria for recognizing these shelves as submerged submarine plains are the following:

1. Central and southern Philippines show strongly embayed shore lines. Caramoan Peninsula, for example, in the region of the Polillo shelf has a very irregular coast line, bordered by a number of islands, and subaërially eroded valleys are now occupied by the sea. The bedrock of the dredging ground of the Mambulao-Paracale gold district is 58 feet (18 meters) below the present level, and the nature of the bottom gravel indicates that it was deposited by streams flowing above sea level. The upper part of the deposit shows evidences of tidal conditions, and the tide reaches for a long distance inland in some of the streams.

2. Cross sections of these submarine plains show that they are bordered either by steep slopes or by escarpments.

3. The presence of caves in limestone below sea level that are supposed to have been formed by the solvent action of fresh water. Malampaya Sound, in northern Palawan, is a submerged river valley of a former erosion cycle, when the elevation of Palawan above the sea was much greater than it is at present. The underground river in St. Paul Bay, which launches can enter from the sea and navigate for about 4 miles, is an underground channel by which underground water formerly flowed to the sea.

TEMPERATURE AND SALINITY MEASUREMENTS

The United States Coast and Geodetic Survey has taken temperature and salinity measurements in the Sulu Archipelago. The Sulu reefs present excellent examples of coral-reef development in the Philippines, and data on temperature and salinity of the water in the area are of peculiar significance, as they present actual conditions obtaining in a region where coral reefs are known to be well developed. The results of these measurements are given in Table 1.

TABLE 1.—*Temperature and salinity measurements, Sulu Archipelago (United States Coast and Geodetic Survey).*

No.	Latitude north.		Longitude east.		Depth.	Temperature.	Salinity: parts per M.	Sublocality, date, character of bottom, etc.
	°	′	°	′	*Fathoms.*	°C.		
1	4	45.0	119	44.0	12	26.5	35.8	Southwest of Tawitawi Island, G. D. Cowie, 1928; white sand.
2	5	30.0	120	05.35	36	26.7	35.6	North of Tawitawi Island, G. D. Cowie, 1928; white sand.
3	5	32.8	120	10.4	12	26.8	34.9	Do.
4	5	29.5	120	14.1	Surface 30	28.9 27.8	37.6 38.0	North of Simaluc Island, L. C. Wilder, 1928; coral and sand.
5	5	29.1	120	14.15	Surface 30.2	28.3 26.1	35.6 34.8	Northeast of Simaluc Island, L. C. Wilder, 1928; coral and sand.
6	5	28.7	120	15.05	Surface 28.0	27.8 27.5	35.4 35.3	Do.
7	5	30.9	120	15.55	Surface 31.5	28.3 26.0	33.0 34.0	Northeast of Simaluc Island, L. C. Wilder, 1928; fine white sand.
8	5	22.3	120	13.4	Surface 20.0	28.3 28.3	33.0 33.0	North of Basbas Island, L. C. Wilder, 1928.
9	5	22.9	120	13.9	Surface 39.5	28.3 24.4	34.8 33.4	Do.
10	5	23.4	120	16.3	Surface 38.8	27.8 24.4	34.0 34.1	Northwest of Tambagaan Island, L. C. Wilder, 1928; coral sand.
11	5	23.9	120	16.45	Surface 38.5	28.0 25.2	36.3 33.7	North of Basbas Island, L. C. Wilder, 1928; coarse white sand.
12	5	24.3	120	18.8	Surface 23.6	27.8 27.8	35.4 35.4	North of Tambagaan Island, L. C. Wilder, 1928; fine white sand.
13	5	22.8	120	20.85	Surface 13.0	27.6 27.9	34.5 34.5	East of Tambagaan Island, L. C. Wilder, 1928.
14	5	25.3	120	21.4	Surface 36.7	27.8 22.2	34.2 32.4	Northeast of Tambagaan Island, L. C. Wilder, 1928; coral sand.

spread as are those formed in the earlier periods, owing in a large measure to the cold climate that prevailed during Pleistocene time, and the consequent reduction in the rate of formation of the coral reefs. The protection coral reefs afforded the shores being thus lessened, the waves of the sea were able to cut fairly extensive submarine plains.

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2	5	30.0	120	05.35	36	26.7	35.6	North of Tawitawi Island, G. D. Cowie, 1928; white sand.
3	5	32.8	120	10.4	12	26.8	34.9	Do.
4	5	29.5	120	14.1	Surface 30	28.9 27.8	37.6 38.0	North of Simaluc Island, L. C. Wilder, 1928; coral and sand.
5	5	29.1	120	14.15	Surface 30.2	28.3 26.1	35.6 34.8	Northeast of Simaluc Island, L. C. Wilder, 1928; coral and sand.
6	5	28.7	120	15.05	Surface 28.0	27.8 27.5	35.4 35.3	Do.
7	5	30.9	120	15.55	Surface 31.5	28.3 26.0	38.0 34.0	Northeast of Simaluc Island, L. C. Wilder, 1928; fine white sand.
8	5	22.3	120	13.4	Surface 20.0	28.3 28.3	33.0 33.0	North of Basbas Island, L. C. Wilder, 1928.
9	5	22.9	120	13.9	Surface 39.5	28.3 24.4	34.8 33.4	Do.
10	5	23.4	120	16.3	Surface 38.8	27.8 24.4	34.0 34.1	Northwest of Tambagaan Island, L. C. Wilder, 1928; coral sand.
11	5	23.9	120	16.45	Surface 38.5	28.0 25.2	36.3 33.7	North of Basbas Island, L. C. Wilder, 1928; coarse white sand.
12	5	24.3	120	18.8	Surface 23.6	27.8 27.8	35.4 35.4	North of Tambagaan Island, L. C. Wilder, 1928; fine white sand.
13	5	22.8	120	20.85	Surface 13.0	27.6 27.9	34.5 34.5	East of Tambagaan Island, L. C. Wilder, 1928.
14	5	25.3	120	21.4	Surface 36.7	27.8 22.2	34.2 32.4	Northeast of Tambagaan Island, L. C. Wilder, 1928; coral sand.

TABLE 1.—*Temperature and salinity measurements, Sulu Archipelago (United States Coast and Geodetic Survey)*—Continued.

No.	Latitude north.		Longitude east.		Depth.	Temperature.	Salinity; parts per M.	Sublocality, date, character of bottom, etc.
	°	′	°	′	*Fathoms.*	°C.		
15	5	26.2	120	23.0	Surface	27.2	32.6	North of Sigboye Island, L. C. Wilder, 1928; broken coral and sand.
					26.5	27.1	33.5	
16	5	20.8	120	22.4	Surface	28.0	35.5	Northwest of Pandanan Island, L. C. Wilder, 1928.
					18.0	28.0	36.3	
17	5	19.8	120	22.1	Surface	27.8	35.4	East-southeast of Tambagaan Island, L. C. Wilder, 1928; coral sand.
					20.0	28.3	35.6	
18	5	23.2	120	23.8	Surface	27.5	34.5	Southeast of Sigboye Island, L. C. Wilder, 1928; coarse white sand.
					18.5	27.7	34.5	
19	5	22.7	120	24.8	Surface	27.8	33.4	South of Sigboye Island, L. C. Wilder, 1928.
					15	28.2	33.8	
20	5	32.1	120	22.5	Surface	28.3	33.0	North of Sigboye Island, L. C. Wilder, 1928.
					30.0	26.0	35.5	
21	5	31.85	120	22.2	Surface	27.8	34.6	Northwest of Sigboye Island, L. C. Wilder, 1928; coarse white sand.
					30.0	25.0	33.6	
22	5	33.2	120	25.9	Surface	28.3	33.9	Northwest of Cacataan Island, L. C. Wilder, 1928; coarse white sand.
					24.9	27.4	32.7	
23	5	32.75	120	25.9	Surface	27.7	34.2	North of Cacataan Island, L. C. Wilder, 1928; coarse white sand.
					16.0	27.2	34.1	
24	5	33.2	120	27.5	Surface	27.4	34.0	Do.
					17.4	26.6	34.2	
25	5	36.1	120	31.1	Surface	28.5	32.3	North-northeast of Cacataan Island, L. C. Wilder, 1928; coarse white sand.
					34.3	25.0	32.7	
26	5	36.7	120	31.65	Surface	24.7	34.3	Northeast of Cacataan Island, L. C. Wilder, 1928; coarse sand.
					34.7	23.3	32.3	
27	5	27.8	120	33.1	Surface	28.3	37.3	North of Maniacolat Island, L. C. Wilder, 1928; coarse white sand.
					33.0	20.6	33.8	
28	5	29.0	120	26.5	Surface	27.8	34.6	Southwest of Cacataan Island, L. C. Wilder, 1928; broken coral.
					31.1	26.0	33.1	
29	5	28.7	120	26.4	Surface	27.2	36.0	Sigboye Pass, L. C. Wilder, 1928; coarse coral.
					32.0	27.6	36.1	
30	5	28.6	120	28.3	Surface	27.8	34.0	South of Cacataan Island, L. C. Wilder, 1928; coarse white sand.
					26.3	26.8	34.1	
31	5	25.3	120	27.15	Surface	27.4	33.8	East of Sigboye Island, L. C. Wilder, 1928; coarse white sand.
					23.4	27.6	34.0	
32	5	24.3	120	27.2	Surface	27.7	34.5	Sigboye Pass, L. C. Wilder, 1928; coarse white sand, broken shells.
					27.0	27.2	35.2	

TABLE 1.—*Temperature and salinity measurements, Sulu Archipelago (United States Coast and Geodetic Survey)*—Continued.

No.	Latitude north.		Longitude east.		Depth.	Temperature.	Salinity; parts per M.	Sublocality, date, character of bottom, etc.
	°	′	°	′	*Fathoms.*	°C.		
33	5	24.5	120	28.1	Surface	27.8	35.4	Southeast of Sigboye Island, L. C. Wilder, 1928; coarse white sand.
					22.3	27.3	35.2	
34	5	23.7	120	27.6	Surface	27.8	34.2	Sigboye Pass, L. C. Wilder, 1928; broken coral.
					26.1	27.7	34.3	
35	5	25.2	120	29.8	Surface	27.7	35.3	Sigboye Pass, L. C. Wilder, 1928; red coral.
					16.8	27.7	35.4	
36	5	26.1	120	31.0	Surface	27.8	34.0	Sigboye Pass, L. C. Wilder, 1928.
					26.9	26.0	34.0	
37	5	24.6	120	31.1	Surface	27.2	33.9	Sigboye Pass, L. C. Wilder, 1928; coral sand.
					32.0	22.8	34.6	
38	5	22.85	120	28.45	Surface	27.8	34.2	Sigboye Pass, L. C. Wilder, 1928; coarse white sand.
					27.0	28.0	33.8	
39	5	22.2	120	27.8	Surface	27.6	34.4	Sigboye Pass, L. C. Wilder, 1928; coral sand.
					20.8	26.7	34.3	
40	5	21.6	120	28.7	Surface	27.7	34.1	Sigboye Pass, L. C. Wilder, 1928; broken coral.
					28.4	27.2	34.1	
41	5	18.2	120	30.1	Surface	27.8	35.4	Southeast of Sigboye Island, L. C. Wilder, 1928; broken coral.
					21.8	27.7	35.4	
42	5	18.3	120	30.8	Surface	27.6	34.1	West of Tagao Island, L. C. Wilder, 1928; broken coral.
					19.5	28.3	34.9	
43	5	17.0	120	32.5	Surface	27.8	34.0	Southwest of Tagao Island, L. C. Wilder, 1928.
					14	27.8	34.0	
44	5	19.8	120	33.1	Surface	27.2	32.6	Northwest of Tagao Island, L. C. Wilder, 1928; coral sand.
					19.5	26.8	33.4	
45	5	22.0	120	33.4	Surface	27.8	37.1	Sigboye Pass, L. C. Wilder, 1928; coarse white sand, red coral.
					20.0	26.4	36.6	
46	5	23.7	120	33.0	Surface	27.8	35.2	Sigboye Pass, L. C. Wilder, 1928; coarse white sand, broken coral.
					27.3	27.6	34.4	
47	5	24.2	120	33.1	Surface	28.2	34.7	Sigboye Pass, L. C. Wilder, 1928; broken coral and broken shells.
					31.2	27.6	33.6	

The temperature measurements are made only at the surface and at depths not exceeding 40 fathoms. The lowest bottom temperature recorded is 20.6° C. at a depth of 33 fathoms, and the average of temperature measurements of depths between 30 and 40 fathoms is 25° C. It will be remembered that these temperatures are much higher than the lower limit recorded by Vaughan,[4] which is an annual minimum not below

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[4] Smithsonian Report for 1917, Washington (1919) 215.

18° C. There is a gradual decrease in temperature from the surface to the bottom for the great majority of records, although eight measurements (Nos. 13, 17, 18, 19, 29, 31, 38, and 42) show slight increases from 0.2° to 0.7° from surface to bottom. Those showing the same or a little higher readings are in a channel communication between Celebes Sea and Sulu Sea. The readings from 32- to 40-fathom depths show a decrease of temperature from 2.8 to 7.7° C. as compared with surface records and an average of 4.3° C.

The salinity measurements do not show any apparent stratification. As a matter of fact, nineteen readings show more salinity at the surface than at the bottom, eighteen other readings show more salinity at the bottom than at the surface, and seven readings have the same salinity at the surface and at the bottom. The highest salinity recorded is 38 parts per thousand at 30 fathoms and the lowest 32.3 at 34.7 fathoms. It will be recalled that the figures given by Vaughan[5] for salinity requirements is between 27 and 38 parts per thousand.

TERTIARY AND PLEISTOCENE REEF CORALS AND CORAL REEFS

The ancient coral reefs of the Philippine Islands have been studied only superficially. Many of these reefs have yielded an abundance of coral species, which are being studied, classified, and named. The coralliferous beds are known in many parts of the Islands, notably along the coasts where they occur as elevated reefs, and also in the interior where they are found in patches and at altitudes up to 1,950 meters (6,318 feet), as on Mount Santo Tomas, near Baguio in Mountain Province. As a matter of fact all provinces and the great majority of the smaller islands have fossil-coral localities. Cebu Island, however, presents the best conditions for the study of reef corals and coral reefs.

SUMMARY AND CONCLUSIONS

The general results of the foregoing preliminary survey may be summarized as follows:

1. Living coral reefs are best developed in the central and southern part of the Philippines, more particularly in the region of the submerged banks and shelfs; namely, on the Palawan shelf, the Sulu shelf, the Visayan shelf, and the Polillo shelf.

2. The majority of the fringing reefs are limited in breadth, rarely exceeding 3 miles and averaging less than 1 mile wide.

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[5] Loc. cit.

This condition is taken as a proof of the apparent instability of the Philippine land mass so that only in very few places has the coast line remained stationary sufficiently long to permit the fringing reef that has developed to increase in breadth by outward growth.

3. Coral reefs have grown and developed whenever and whereever conditions are satisfactory for the growth and development of corals. In other words depth, temperature, ocean currents, salinity, and other conditions have been responsible for the location of coral reefs rather than the presence of any land area. The form developed by the growing reefs is determined principally by the ocean currents and the direction of the wind so that the generally accepted classification of fringing, barrier, and atoll reefs should not be taken with evolutionary significance but rather convenient forms as means of reference. In addition to the reefs fringing the larger and smaller islands there are very many coral-reef patches not rising above the sea level, some distance from the land, surrounded by deeper waters and apparently without connection with the neighboring reefs. To this class of reefs the term shoal reef has been applied. The fringing reefs do not have the same extension from the shore line, but in a great many cases project for some distance beyond the end or point of the island, and in some cases do not follow the shore line but form a spit or take a direction tangent to the coast.

4. Tertiary and Pleistocene coral reefs are widely scattered throughout the Archipelago and their geologic history can be ascertained.

ILLUSTRATIONS

PLATE 1

Map of the Philippine Islands showing land in black and submarine shelves in hatchings. Based upon Coast and Geodetic Survey map No. 4200.

PLATE 2

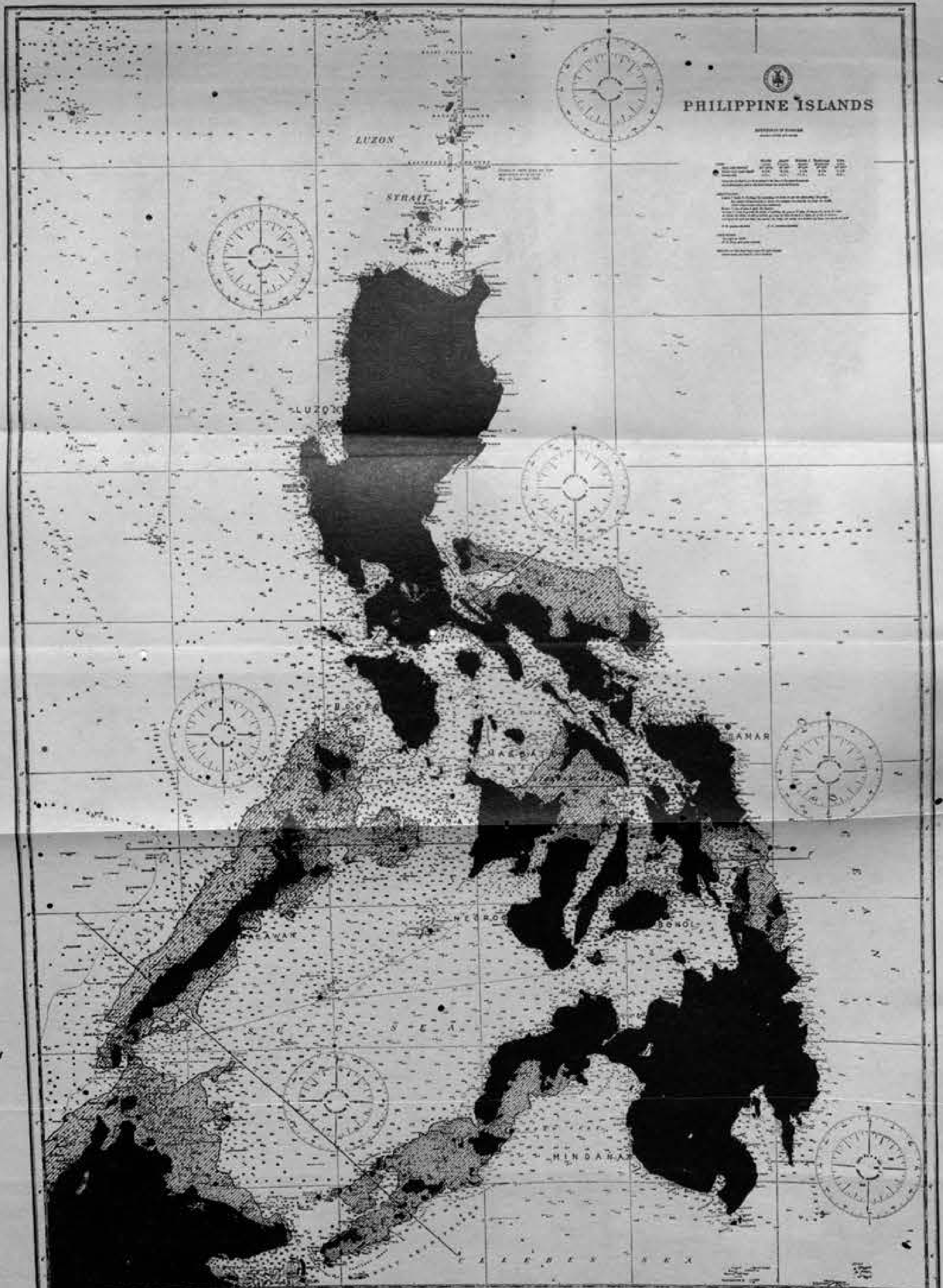
FIG. 1. Coralliferous limestone cliff, Cebu.
2. Underground river in St. Paul Bay, Palawan.

PLATE 3

FIG. 1. Maeander Reef, Sulu Sea.
2. Fringing reef, west coast of Luzon, partly exposed at low tide.
3. Coast near Santa, Ilocos Sur, west coast of Luzon, showing raised coral reefs on Abra fault scarp. (Photograph by Bailey Willis.)

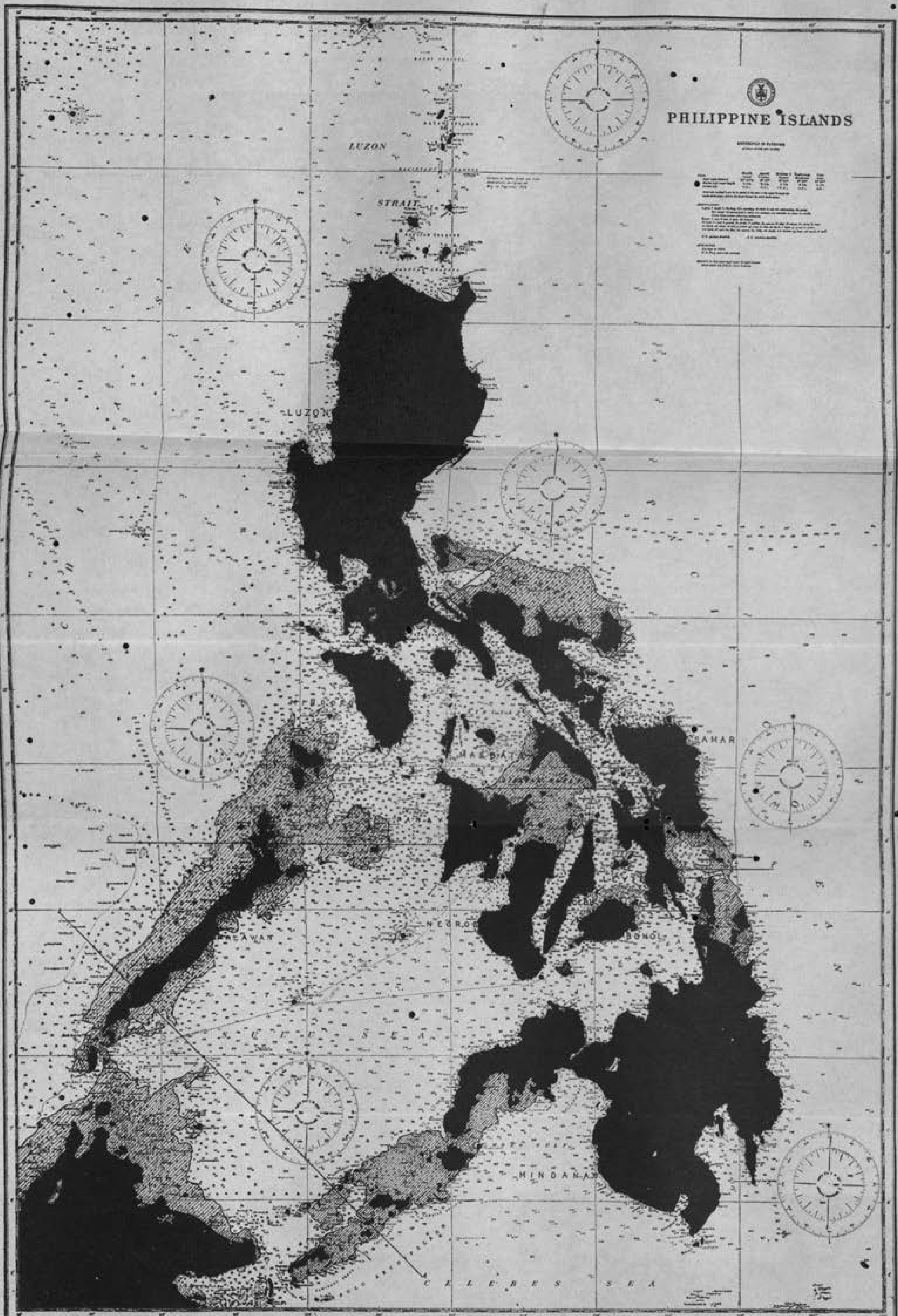
TEXT FIGURES

FIG. 1. Cross section of the Polillo shelf.
2. Cross section of the Visayan shelf.
3. Cross section of the Leyte-Samar shelf.
4. Cross section of the Palawan shelf.
5. Cross section of the Palawan shelf and the Sulu shelf.



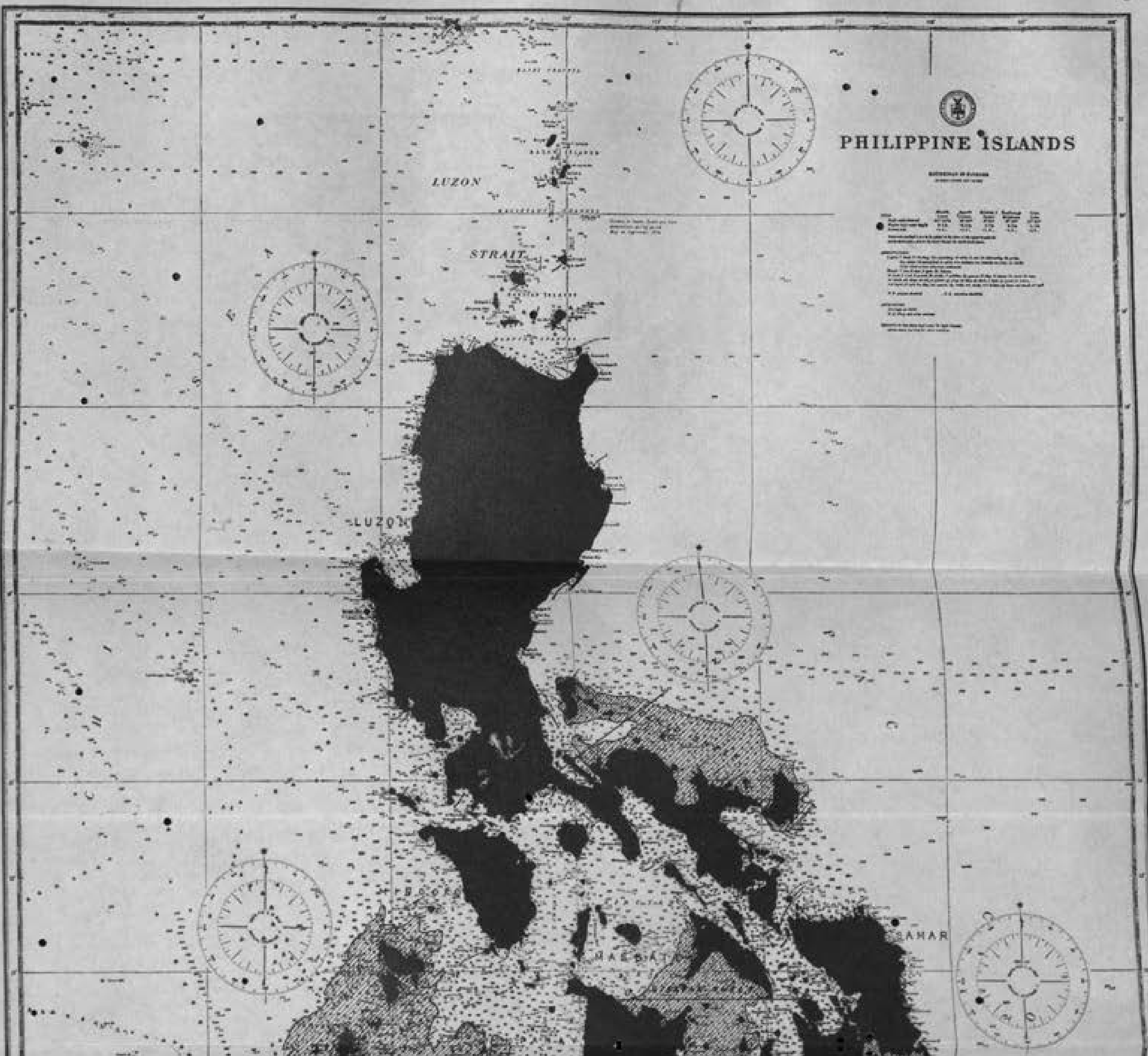
The Philippine Islands showing land in black and submarine shelves in hatchings. Based upon coast and Geodetic Survey map No. 4200.

PLATE 1.



The Philippine Islands showing land in black and submarine shelves in hatchings. Based upon coast and Geodetic Survey map No. 4200.

PLATE 1.



The Philippine Islands showing land in black and submarine shelves in hatchings. Based upon coast and Geodetic Survey map No. 4200.

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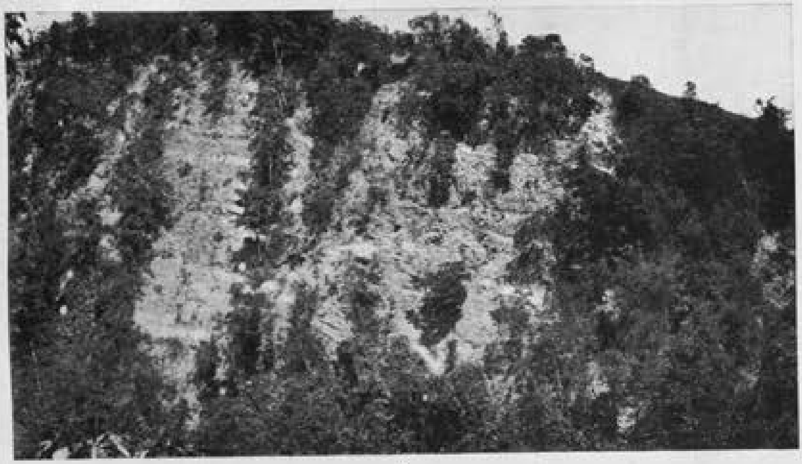

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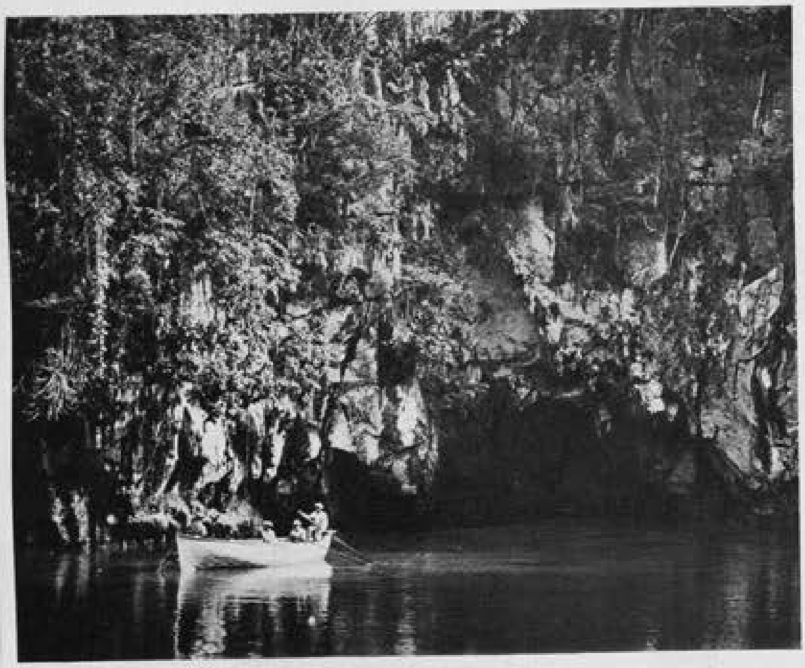

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PLATE 2.

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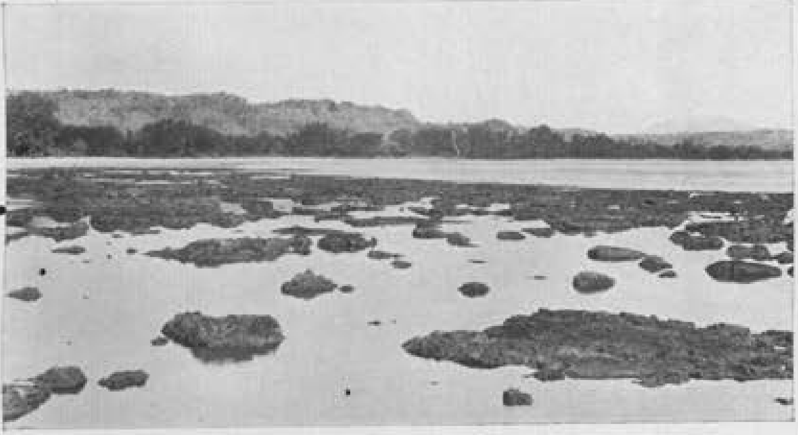

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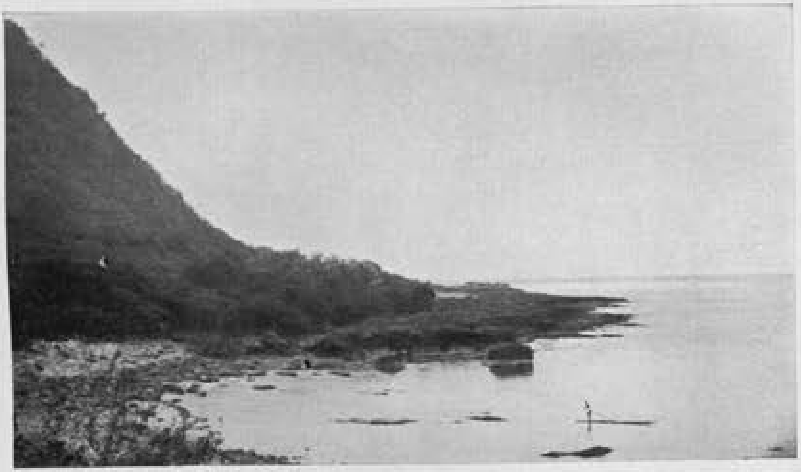

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PLATE 3.

A SURVEY OF MONGREL DOGS OF MANILA, PHILIPPINE ISLANDS, FOR HELMINTHIC AND BLOOD PROTOZOAN PARASITES[1]

By JOE H. ST. JOHN, JAMES S. SIMMONS
Majors, Medical Corps, United States Army

and

FRANCOIS H. K. REYNOLDS
Captain, Veterinary Corps, United States Army

The present report of a survey of mongrel dogs at large in the City of Manila, Philippine Islands, for helminthic and blood protozoan parasites is based in the first instance on autopsy examinations of fifty, and in the second on the examination of thin blood smears from one hundred dogs. Aside from the recording of the index of parasitization of dogs in the Philippines, this report may be of interest in showing that the helminthic rate of infestation of dogs in Manila is not greater than would be expected in cities of similar size of temperate climates.

TABLE 1.—*Result of the survey for helminths present in fifty dogs.*

Parasite.	Dogs positive.	Number of helminths present.		
		Maximum.	Minimum.	Average.
	P. ct.			
Ancylostoma caninum	100	169	2	32.34
Dipylidium caninum	34	20	1	10.29
Wuchereria immitis	10	4	2	2.20
Toxacaris canis	4	6	2	4.00

Only one species of hookworm was found; namely, *Ancylostoma caninum.* This species was present in all the dogs examined. The average number present per dog was 32.34. Only two, or 4 per cent, of the dogs harbored more than one hundred hookworms, while in 40 per cent of the animals there were less than fifty per dog.

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[1] From the United States Army Medical Department Research Board, Bureau of Science, Manila, Philippine Islands.

The filaria were found in the right side of the heart, and in each animal the peripheral blood contained the larval forms.

In the examination of one hundred dogs for blood parasites, 4 per cent were positive for *Babesia canis*. All of these positive dogs were approximately half grown. Smears from the older dogs were negative.

With one exception, all the *Babesia* infections were light; the parasites numbering approximately three to five per drop of blood. In one instance a leukemia coexisted with a heavy infection; the total white blood cells present in this instance was 340,000 per cubic millimeter and the differential count was as follows:

	Per cent.	Per cent.
Polymorphonuclears		33.4
Young neutrophiles	9.2	
"Staff" forms	19.8	
"Segmented" forms	4.2	
Eosinophiles	0.2	
Basophiles	0.0	
Monocytes (?) and lymphoblasts		49.0
Lymphocytes		17.6

Of the lymphoblasts, eight were of the lobulated or "Reider" type. "Inclusion bodies" (nucleoli) were seen in twelve lymphoblasts (?) and one lymphocyte.

Only one species of tick was found infesting the dogs positive for *B. canis;* namely, *Rhipicephalus sanguineus*. Transmission experiments of *B. canis* were conducted with *R. sanguineus* removed from infected dogs as follows:

EXPERIMENT 1

March 5, 1930.—Four nursing puppies, 3 weeks old, and the mother were used. Preliminary smears were negative for *B. canis,* but all dogs were infested with *R. sanguineus.* Ticks collected February 2, 1930, from positive dogs 40 and 183, were placed on all. March 11 one of the puppies was positive and died as a result of the infection March 12. The infection in this instance was heavy, nearly every cell being parasitized and some cells contained multiple pairs. Smears from the three other puppies were negative, but March 19 a scant infection was noted in the mother dog, but this animal never became ill.

EXPERIMENT 2

March 20, 1930.—Ticks (*R. sanguineus*) were removed from the mother dog noted in experiment 1 and placed on half-grown dog 2. March 25 the dog was very sick, all food was refused, and it was difficult for her to stand. Smears were positive for *B. canis* on this date; the degree of infection was regarded as moderate. The blood remained positive for a period of seven days, after which the animal recovered.

As it is already well known that *Rhipicephalus sanguineus* is the common transmitting agent of *B. canis* in other parts of the world, the experiments reported above were planned merely to obtain evidence that this tick is probably the common vector of *B. canis* in the Philippines. The results of experiments 1 and 2 indicate that the incubation period of tick-transmitted piroplasmosis in dogs is about five days, and that the virulence of the infection decreases with the age of the definitive host. This is in accordance with well-known facts.

SUMMARY

1. At autopsy on fifty dogs obtained in the City of Manila, it was found that with the exception of filaria, the percentage infested with and the average number of helminths present per dog were not greater than would be expected in stray dogs in cities of temperate climate.

2. In a survey of one hundred dogs for blood protozoan parasites, 4 per cent were positive for *Babesia canis*. This parasite was transmitted experimentally in three instances from dogs found infected in nature to healthy animals, by *Rhipicephalus sanguineus*.

3. The results of the transmission experiments of *Babesia canis* by *Rhipicephalus sanguineus* indicate that the incubation period of piroplasmosis in dogs is about five days and that the infection may be severe in young, moderate in half-grown, and mild in older dogs.

THYROID GLAND OF THE CARABAO

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Of the College of Veterinary Science, Los Baños, Laguna

TWO PLATES AND TWO TEXT FIGURES

The thyroid gland, peculiar to mammals (1910), has engaged the attention of many investigators, among whom the following may be mentioned: Rumph and Smith (1926), Kull (1926), Moody (1910), Norris (1916), Cowdry (1922), Bensley (1916), Jackson (1916), Major (1909), Hammet (1927), Dye and Manghan (1929), and Williamson (1926). A survey of their respective work, however, has shown that their attention has been focused principally upon the histogenesis, morphogenesis, and physiology of the gland, and upon the rôle it plays in the growth of various organs. It has been noted also that literature on hand bearing on the anatomy of the thyroid gland of various domestic animals fails to show any previous description of this gland in the carabao. The study here reported was undertaken in an attempt to gain some information on the subject; it is believed that this will be of interest to students of comparative anatomy.

The following account is based upon the data obtained from the dissection of the ventral part of the necks of ten carabaos of different ages and microscopic examination of the thyroid gland found in each animal.

COMPARATIVE ANATOMY

According to Sisson (1917) the thyroid gland of the ox is pale in color in the adult and dark red in the calf, and it is softer in texture than in the horse. The lateral lobes average about 8 centimeters in length and are irregularly triangular in outline and more extensive and flatter than in the horse. They are situated on each side of the trachea near to or in contact with the larynx; in addition to the trachea they are also related deeply to the œsophagus and the cricopharyngeal muscle to a varying extent. The isthmus is constantly present and glandular.

In the sheep (Sisson) the thyroid gland is dark red. The lateral lobes, which are long elliptical in outline, lie on each side of the neck over the first six or seven tracheal rings. Each lobe is from 5 to 6 centimeters in length and about 1.5 centimeters in height. The isthmus is also constantly present and glandular.

Vaughan (1909), Bradley (1896), and M'Fadyean (1910) describe the thyroid gland of the horse as brownish red. The lateral lobes are ovoid in outline and are joined by a narrow isthmus; the latter is sometimes reduced to a small strand of fibrous connective tissue. According to Vaughan and Bradley the lateral lobes are related to the upper part of the trachea on each side, resting on the first two tracheal rings, but M'Fadyean states that they lie over the first four tracheal rings.

Caylor and Schlotthauer (1927) made a very comprehensive and thorough study of the anatomy of the thyroid gland of swine, and according to these investigators it is situated on the ventral surface of the trachea in the median line just anterior to the thoracic inlet, in the angle formed by the carotid arteries and the jugular veins. The two lateral lobes are fused in the median line so as to form a single organ. It is deep red, and the average dimensions in adult swine are 6 by 4 by 3 centimeters.

In the dog (1917), the lateral lobes of the thyroid gland are long and narrow, and have a flattened, ellipsoidal form. They are situated on the lateral surface of the trachea near the larynx, extending along the first six or seven tracheal rings. The isthmus is inconstant and variable, being present always in large, but not in small species.

GROSS ANATOMY OF THE THYROID GLAND OF CARABAO

COLOR, FORM, SIZE, AND LOCATION

Carabao calf, about 2 years old.—The thyroid gland of this animal was brownish red, and the lateral lobes, which were connected by a rather wide glandular isthmus—double in its middle part—were asymmetrical in position, size, and form. The left lateral lobe was somewhat compressed laterally, having convex superficial surface and slightly concave deep surface. It was more or less elliptical in outline, and its anterior end was very much thicker than the posterior one. The latter was further characterized by the presence of a tail-like projection. This lobe was situated along the dorsolateral part of the first four tracheal rings, its anterior end coming in contact with the cricothyroideal muscle. It was 3.8 centimeters in length and 1.7 centimeters in height. The right lateral lobe was more or less bean-shaped and much smaller than its fellow, being 1.7 centimeters in length and 1.5 centimeters in height. It was observed to be lying along the first two tracheal rings only.

Carabao bull, about 3 years old.—The thyroid gland in this animal differs from that of the preceding one only in size and form of its lobes. The left lobe was more or less elliptical in outline and 4 centimeters in length by 2 centimeters in height, while the right lobe was ovoid in form and 1.9 centimeters in length by 1.7 centimeters in height.

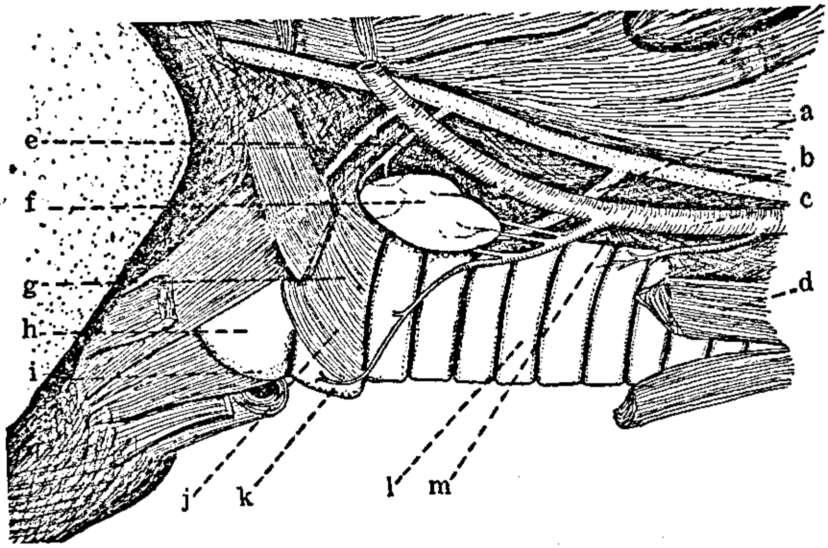

FIG. 1. Left side of the neck (dissected) of an adult carabao, showing the form, location, and blood supplies of the left lateral lobe of the thyroid gland. *a*, Posterior thyroid artery; *b*, common carotid artery; *c*, internal jugular vein; *d*, sternothyrohyoideus; *e*, thyrolaryngeal artery; *f*, left lateral lobe of the thyroid; *g*, *j*, cricothyroideus; *h*, thyroid cartilage; *i*, laryngeal prominence; *k*, arch of cricoid cartilage; *l*, tracheal cartilage; *m*, œsophagus.

Carabao bull, about 4 years old.—The thyroid gland here was likewise brownish red. The left lateral lobe was in the form of a hen's egg; it was over the first three tracheal rings and the posterior half of the cricoid cartilage. It measured 4.2 centimeters in length and 2.7 centimeters in its greatest height. The broader posterior end or pole was much thicker than the anterior one. The right lateral lobe was more or less ovoid, and it lay over the first three tracheal rings only. This lobe was shorter than the left one, its length being 3.5 centimeters only; its greatest height, however, was 2.7 centimeters. The isthmus was broad and distinctly glandular, and it was attached to the middle of the ventral border of the right lateral lobe and to the ventral border of the left lobe a short distance behind its middle.

Carabao bull, about 7 years old.—In this carabao the thyroid gland was no longer brownish red but dark red. The lateral lobes were observed to be asymmetrical both in size and form. The left lobe was more or less ellipsoidal in outline; it was situated on the dorsolateral aspect of the trachea, lying along the first three tracheal rings and the cricoid cartilage. It measured 4.5 centimeters in length and 2.8 centimeters in height. The right lobe was more or less triangular in outline and much flatter than its fellow. It lay along the first three tracheal rings and measured 3.7 centimeters in length and 3 centimeters in height. Its ventral angle was connected to the middle of the ventral border of the opposite lobe by a narrow isthmus which was very much lighter in color than the lobes.

Carabao cow, about 9 years old.—The gland in this animal was also dark red. The left lateral lobe was rather elongated, having a rounded anterior end and a blunt-pointed posterior end. It extended along the first four tracheal rings and the cricoid cartilage. Its length was 5.2 centimeters, and its greatest height was 2.3 centimeters. The right lateral lobe was very much flattened and irregularly triangular in outline, having its base directed dorsally; its ventral angle was prolonged to a short narrow band which was apparently the only glandular part of the isthmus, the continuation of the latter to the opposite lobe being represented only by fibrous connective-tissue strands. The anterior and posterior angles are rounded; the lateral surface was smooth and slightly convex while the medial surface was irregularly concave. This lobe was in contact with the first two tracheal rings and the posterior half of the cricoid cartilage. Its base was 3.8 centimeters in length, and its height was 4.2 centimeters.

Carabao bull, about 10 years old.—Except for a little difference in the size of the lateral lobes, the thyroid gland in this animal was essentially identical to that of the preceding one.

Carabao cow, about 12 years old.—The thyroid gland in this animal was dark red. The left lateral lobe, which was ellipsoidal in outline, extended over the first three tracheal rings

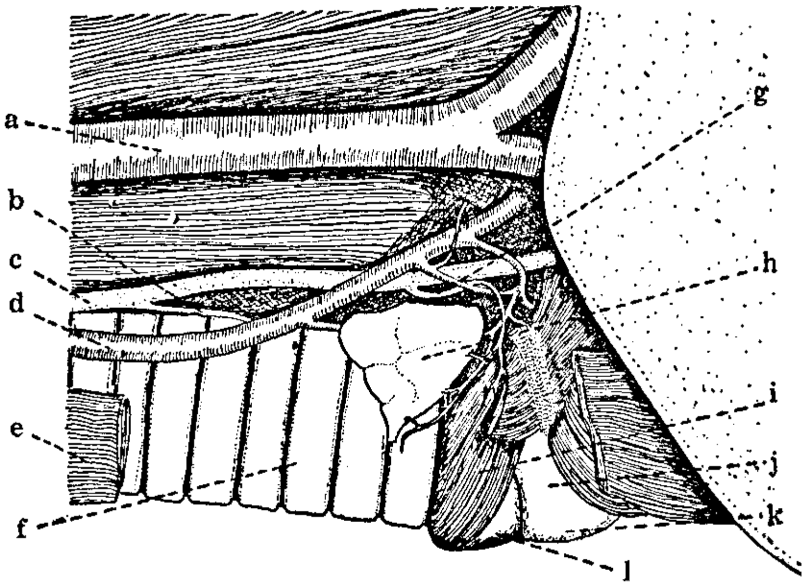

FIG. 2. Right side of the neck (dissected) of an adult carabao, showing the form, location, and blood supplies of the right lateral lobe of the thyroid gland. *a*, External jugular vein; *b*, posterior thyroid artery; *c*, common carotid artery; *d*, internal jugular vein; *e*, sternothyrohyoideus; *f*, tracheal cartilage; *g*, thyrolaryngeal artery; *h*, right lateral lobe of the thyroid gland; *i*, cricothyroideus; *j*, thyroid cartilage; *k*, laryngeal prominence; *l*, arch of cricoid cartilage.

and the cricoid cartilage. It was 4.8 centimeters in length and 3 centimeters in height. The right lateral lobe was more or less triangular in outline and it lay along the first three tracheal rings. It measured 3.7 centimeters in length and 3.9 centimeters in height. The isthmus was represented only by a narrow strand of fibrous connective tissue connecting the ventral angle of the right lobe and the ventral border of the left lobe a short distance behind its middle.

Castrated male carabao, about 15 years old.—The thyroid gland here was also dark red. The left lateral lobe was elliptical and extended over the first three tracheal rings and the cricoid cartilage. It was 4.8 centimeters in length and 2.8 centimeters in height. The right lateral lobe was also flattened and irregularly triangular. This lobe was in contact with the first three tracheal rings and part of the cricoid cartilage. It measured 3.8 centimeters in length and 4.2 centimeters in height. The isthmus could not be distinguished.

Carabao cow, about 18 years old.—In this animal the left and right lateral lobes were practically the same in outline and location as those in the preceding animal. The left lateral lobe was 4.8 centimeters in length and 3.2 centimeters in height, while the right one was 5 centimeters in length and 4.6 centimeters in height. The gland was likewise dark red. The isthmus was totally absent.

Castrated male carabao, about 20 years old.—The thyroid gland here was almost similar in all respects to that of the 18-year old carabao cow.

RELATIONS

The thyroid gland in all the carabaos studied, irrespective of sex and age, was observed to possess a rather dense connective-tissue capsule by means of which its lateral lobes were loosely attached to the trachea. It has been noticed also that the thyroid gland in this animal has practically the same relations as in the ox. Superficially it is related to the external thyrohyoideus, omohyoideus, part of the parotid gland internal jugular vein, vagus and sympathetic nerves, and deeply to the dorsolateral aspect of the anterior part of the trachea, cricothyroideal muscle, and the œsophagus. Sometimes the right lateral lobe of the thyroid gland does not come in contact with the œsophagus.

BLOOD SUPPLY

Summing up the observations on all the animals dissected, the blood supply of the thyroid gland in the carabao may be described as follows: Each lateral lobe of the thyroid gland of the carabao receives blood from two collateral branches of the common carotid artery, the thyrolaryngeal artery and a branch which corresponds to the posterior thyroid artery in the horse. The thyrolaryngeal artery on either side is very short and not infrequently smaller than the corresponding posterior thyroid artery. It divides into two principal branches; namely, the laryngeal artery and the thyroid artery. The laryngeal artery gives rise to small branches which ramify the intrinsic muscles of the larynx. On the right side the thyroid artery enters the gland along the anterior border and at the anterior angle by means of numerous small branches. On the left side the artery enters the gland at the anterior pole. The posterio thyroid artery is variable in size and origin in different subjects and sometimes also in the same individual. It is generally larger, however, than the thyrolaryngeal artery. On the righ side it may arise as far back as the level of the ninth tracheal ring, and on reaching the gland it breaks into three or more primary branches which penetrate the gland at the posterior end or angle. The left posterior thyroid artery is usually larger than its fellow and it arises farther in front; it enters the posterior end of the left lateral lobe by two or three branches. The corresponding thyroid veins are large and empty into the internal jugular vein.

MICROSCOPIC ANATOMY

The microscopic appearance of the thyroid gland of the carabao resembles very closely that in other animals. The follicles vary greatly in size, form, and the diameter of the lumen. Sections of the majority of them, however, are round or ovoid in form; those that are far apart from each other, separated by much interfollicular connective tissue, are generally spherical, whereas those that are closely packed are pentagonal or hexagonal in outline. The follicles near the capsule and the primary trabeculæ are generally smaller and less distended, and the colloid they contain is much more vacuolated than in the interior. In the interior of the gland are found a few exceptionally large follicles containing colloid substance in which red blood corpuscles are embedded. The small follicles are lined by simple epithelium whose cells are typically cuboidal; the large ones, especially those that are distended with colloid, the epithelial cells are almost pavement in type. The epithelial cells lining the empty follicles are more or less short columnar in type.

The interfollicular tissue is relatively greater in amount in areas where the majority of the follicles are small. In the interfollicular tissue or stroma are seen epithelial cells which are irregularly scattered; blood capillaries are likewise observed. Lymphocytes are also found in the stroma in small numbers; they are more numerous at the periphery of the gland. In the interior of the lobe are recognized areas with few small follicles between which, the stroma is closely packed with epithelial cells. The blood capillaries in the interfollicular tissue between adjacent large follicles are hardly, if ever, distinguishable. There appear no marked differences between the microscopic picture of the thyroid gland from a young animal and that from a full-grown or old one, the size and the number of follicles as well as the proportion between the cellular elements and the colloid substance being practically identical.

SUMMARY AND CONCLUSIONS

1. The present account is the result of an investigation on the gross and microscopic anatomy of the thyroid gland of ten carabaos which, so far as I am aware, has not yet been reported.

2. The thyroid gland of the carabao is bilobed as in the ox, sheep, horse, and goat, and the lateral lobes are generally brownish red in young animals but dark red in adults.

3. The left and right lateral lobes of the thyroid gland in young animals vary in shape, but in full-grown individuals, irrespective of sex, the left lobe is generally elliptical or ellipsoidal in outline and the right one irregularly triangular.

4. In full-grown animals the left lobe measures from 4.5 to 5.2 centimeters in length and 2.3 to 3.2 centimeters in its greatest height, and the right lobe varies from 3.7 to 4 centimeters in length and from 3 to 4.6 centimeters in height. Invariably, both in the young and adult animals, the right lateral lobe is flatter and less voluminous than the left one.

5. The isthmus is constantly present and glandular in young subjects, but in adults it may be represented only by fibrous connective-tissue strands; in old subjects it is generally absent.

6. In the adult carabao the lateral lobes of the thyroid gland are situated along the dorsolateral aspect of the trachea, extending over the first three tracheal rings and the posterior half of the cricoid cartilage. Not infrequently the right lateral lobe does not extend so far forward as to lie over the cricoid cartilage. In young animals the position of this gland varies a little.

7. The thyroid gland in the carabao has practically the same relations as in the ox; the right lateral lobe, however, is not always in contact with the œsophagus.

8. The gland receives its blood supply from the thyrolaryngeal artery and from another collateral branch of the common carotid artery which corresponds to the posterior thyroid artery in the horse. The corresponding thyroid veins are radicles of the internal jugular.

9. The microscopic anatomy of the thyroid gland of the carabao does not materially differ from that of other animals. The microscopic appearance of the gland from the young animal presents no striking difference from that of the adult.

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ILLUSTRATIONS

PLATE 1

Photograph of the ventral aspect of the neck (partly dissected) of a carabao about 10 years old, showing the location of the lateral lobes of the thyroid gland. *a*, *a'*, Lateral lobes of the thyroid gland; *b*, internal jugular vein; *c*, common carotid artery; *d*, external jugular vein; *e*, sternothyrohyoideus; *f*, omohyoideus. (Photograph by the College of Agriculture.)

PLATE 2

Microphotograph of a section through the lateral lobe of the thyroid gland of a carabao 7 years old. *a*, Colloid substance with red blood corpuscles in one of the exceptionally large follicles in the interior of the lateral lobe. (Photograph by the Bureau of Science.)

TEXT FIGURES

FIG. 1. Sketch of the left side of the neck (dissected) of an adult carabao, showing the form, location, and blood supplies of the left lateral lobe of the thyroid gland. *a*, Posterior thyroid artery; *b*, common carotid artery; *e*, internal jugular vein; *d*, sternothyrohyoideus; *e*, thyrolaryngeal artery; *f*, left lateral lobe of the thyroid; *g*, *j*, cricothyroideus; *h*, thyroid cartilage; *i*, laryngeal prominence; *k*, arch of cricoid cartilage; *l*, tracheal cartilage; *m*, œsophagus.

2. Sketch of the right side of the neck (dissected) of an adult carabao, showing the form, location, and blood supplies of the right lateral lobe of the thyroid gland. *a*, External jugular vein; *b*, posterior thyroid artery; *c*, common carotid artery; *d*, internal jugular vein; *e*, sternothyrohyoideus; *f*, tracheal cartilage; *g*, thyrolaryngeal artery; *h*, right lateral lobe of the thyroid gland; *i*, cricothyroideus; *j*, thyroid cartilage; *k*, laryngeal prominence; *l*, arch of cricoid cartilage.

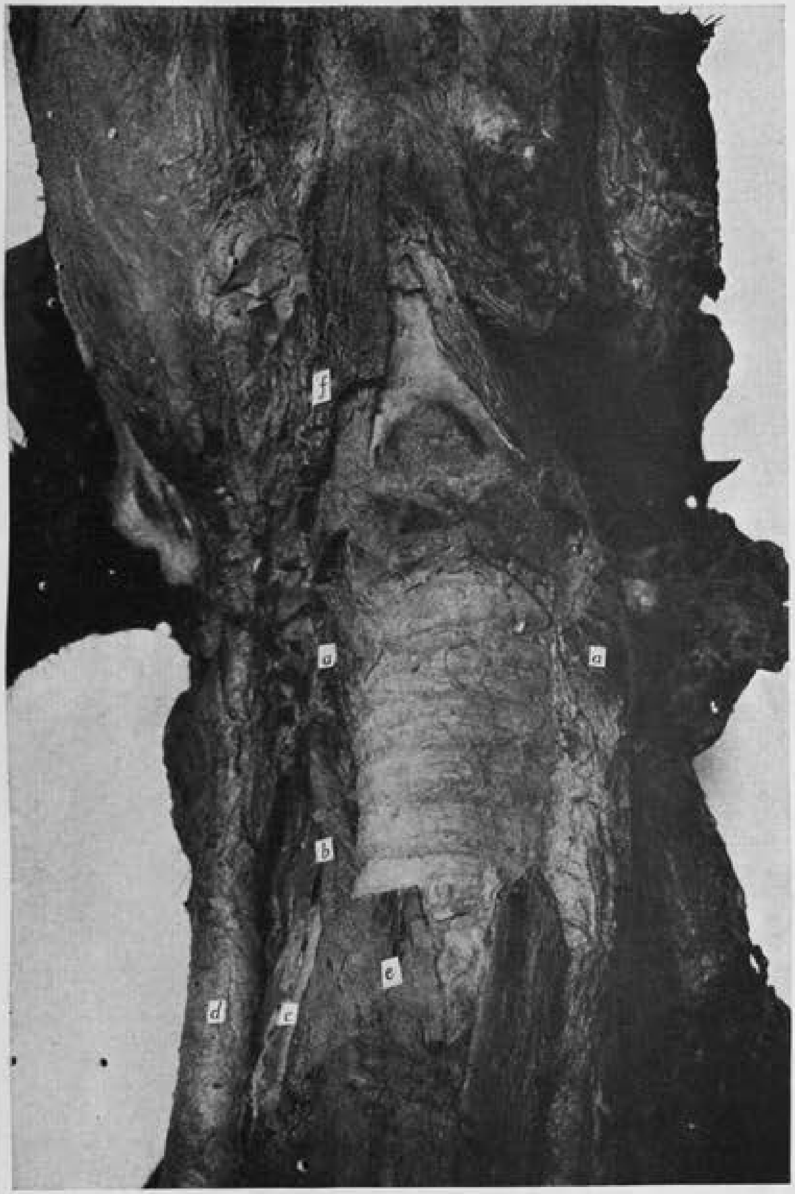

PLATE 1. VENTRAL ASPECT OF THE NECK (PARTLY DISSECTED) OF A CARABAO ABOUT 10 YEARS OLD, SHOWING THE LOCATION OF THE LATERAL LOBES OF THE THYROID GLAND.

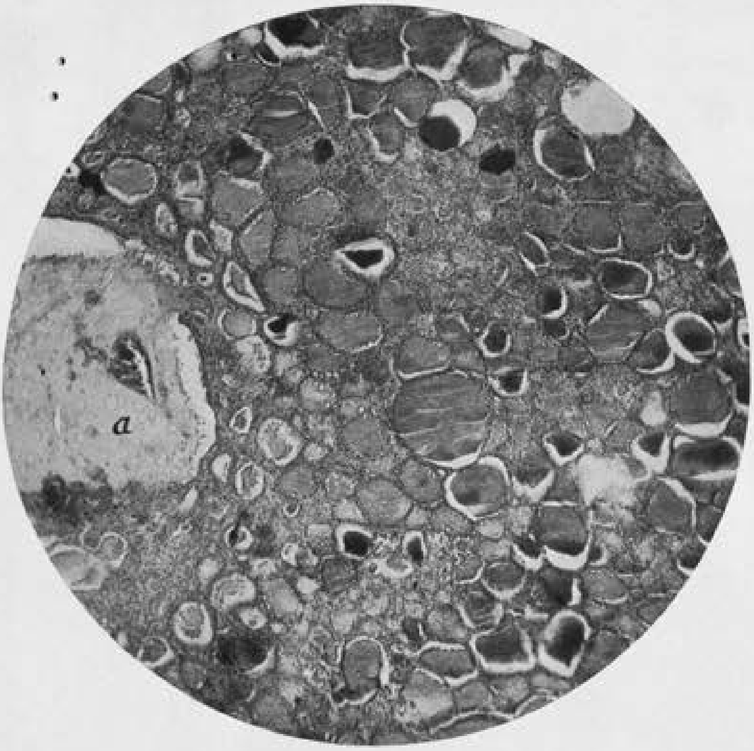

PLATE 2. SECTION THROUGH THE LATERAL LOBE OF THE THYROID GLAND OF A CARABAO 7 YEARS OLD.

VITAL-CAPACITY STUDIES AMONG FILIPINOS

VITAL-CAPACITY STANDARDS FOR MEN FROM 15 TO 30 YEARS OF AGE

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Of the Department of Physiology and Biochemistry, College of Medicine University of the Philippines, Manila

THREE TEXT FIGURES

INTRODUCTION

The present paper is the first of a series intended to establish vital-capacity standards for Filipinos and is limited to males between the ages of 15 and 30 years. The subjects are mostly university students, and a few laboratory helpers and laborers, who, from the negative findings on medical examination, may be considered as enjoying normal health. The university students were examined in the Department of Physical Education, University of the Philippines, in conjunction with the routine medical examinations conducted annually by the university physician, to whom we wish to express our gratitude for his coöperation and for the privileges extended that made this investigation possible.

APPARATUS AND METHODS

The determinations were made with a carefully calibrated aluminum spirometer, whose light weight made vital-capacity measurements accurate and easy for the subject. The technic consisted in standing directly before the apparatus, taking as deep an inspiration as possible, and then with closed nostrils, delivering all the air in the lungs into the mouthpiece of the spirometer. The procedure was repeated two or three times in each case, and the average of the readings that checked to within 20 cubic centimeters was taken as the vital capacity. This 20 cubic centimeter leeway was allowed because in many nervous subjects closer checks in the same individual were difficult to obtain. The three trials were adopted as a routine because in a large number of cases the first reading tended to be low. The respiratory muscles, like other muscles in the body, require a preliminary "warming up" before reaching optimum efficiency. After the third reading, the effect of fatigue tends to decrease the vital capacity. The heights and weights were taken with the subjects stripped. All records were kept in the metric system, and fractions of a unit were eliminated if less than one-half and taken as one if more than one-half.

PREPARATION OF THE STANDARDS

Several vital-capacity standards have been devised by workers interested in the subject. Myers, in his monograph on vital capacity,(1) finds three fairly satisfactory standards; namely, one based on standing height, one on body weight, and one on body-surface area; the last is considered the best of the three. Other standards are based on formulas developed from measurements of chest circumference, trunk length, etc. It would seem that the best way of gaining an idea of the vital capacity is the measurement of the dimensions of the chest, the box that holds the lungs. Nevertheless, owing to the many factors that intervene, Myers finds that these apparently more-precise standards are no better than the first-named three standards when tested on large numbers of subjects.

We have prepared two standards; namely, one based on standing height, and one based on a combination of standing height and body weight. It is felt that these two standards will be sufficient for most practical purposes. The standing-height standard, though less accurate, may be more handy because meter sticks for height measurements are in general more available than balances for weighing. The standard based on a combination of height and weight should be resorted to for greater accuracy.

1. *Standard based on standing height.*—The vital-capacity determinations on our 2,600 subjects were arranged according to height. If all the 2,600 vital-capacity values were plotted against height it would be difficult to determine with any degree of precision the slope of the line that represents the mean of the observations, because of the large number of points to be considered. Hence, the first step taken in preparing this standard was to determine the average of all cases falling within height ranges of 10. The results are given in Table 1, and presented graphically in fig. 1. The points fall fairly uniformly about a straight line. The three cases with unusual height and extremely low vital capacities were disregarded.

The formula for a straight-line graph as determined by the method of least squares(2) is $y = a + bx$. Applying this to

TABLE 1.—*Vital capacity and standing height.*

Number of cases.	Height range.	Mean height.	Vital capacity.	
			Actual average.	Standard.
	cm.	*cm.*	*cc.*	*cc.*
10	131–140	137	1,740	1,837
56	141–150	147	2,175	2,295
864	151–160	157	2,861	2,754
1,447	161–170	165	3,164	3,121
220	171–180	173	3,556	3,488
[a] 1		181	3,350	3,854
[a] 1		188	3,450	4,175
[a] 1		198	2,600	4,634
2,600	Mean	162	3,064	3,007

[a] Not included in the mathematical calculation of the standard.

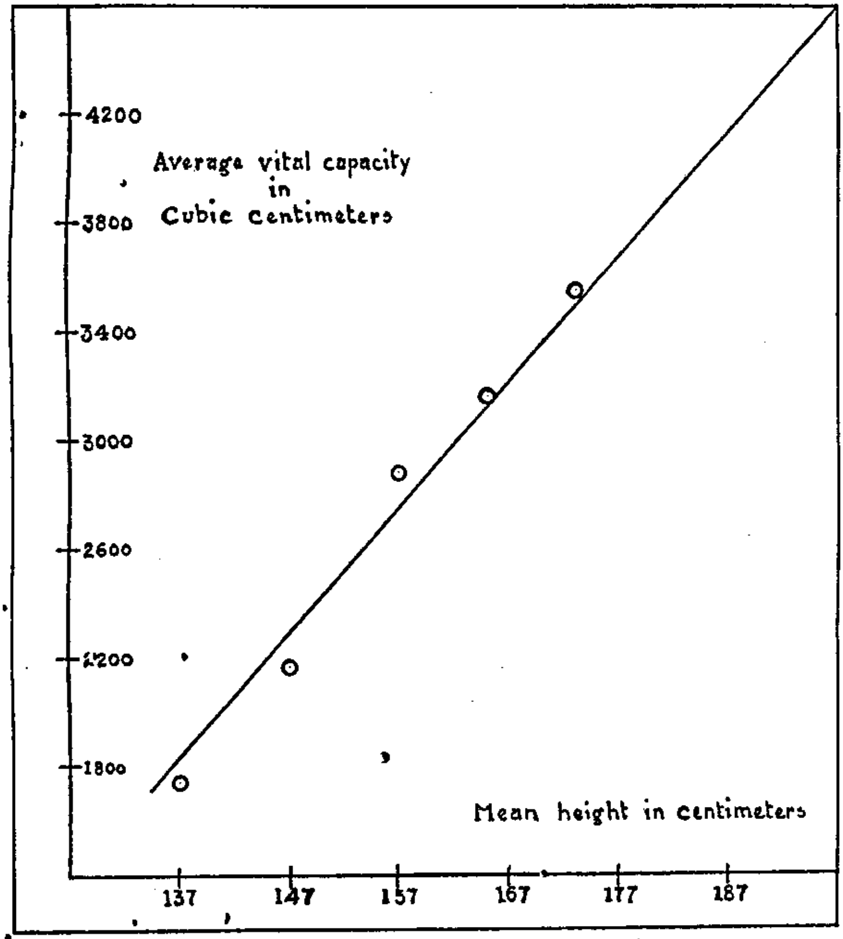

FIG. 1. Vital capacity in relation to standing height.

the data of Table 1 we find a = — 4,444.0 and b = 45.85 where x is the height in centimeters and y is the vital capacity in cubic centimeters.

Whence, V. C. in cc = 45.85 ht (cm) — 4,444.0. By this formula it is possible to predict roughly the vital capacity when the height in centimeters is known.

2. *Standard based on a combination of height and weight.*—The method of expressing vital capacity in liters per square meter of body surface has been found to be the most satisfactory. We have, however, introduced what we believe to be a simpler and even more-accurate criterion for reckoning vital capacity, based on the product of height in centimeters and weight in kilograms. After all, the Dubois formula(3) for estimating body surface is based on weight and height measurements. Moreover, this formula has been developed from studies on Americans, whose body contours are not the same as those of Filipinos. The height in centimeters was multiplied by the weight in kilograms in each of our cases. For convenience this product will henceforth be designated P. All the P's were arranged in groups of 10 and the average vital capacity for each group was determined. The results are shown in Table 2.

TABLE 2.—*Vital capacity and the product Ht × Wt.*

Number of cases.	Height × weight (P).		Vital capacity.		
				In per cent of P.	
	Range.	Mean.	Mean.	Mean.	Standard.
			cc.		
1	3,100–4,000	3,500	1,528	43.6	43.95
19	4,100–5,000	4,600	1,889	41.0	42.73
56	5,100–6,000	5,600	2,296	41.0	41.39
435	6,100–7,000	6,600	2,720	41.2	40.04
870	7,100–8,000	7,500	3,001	40.0	38.55
718	8,100–9,000	8,500	3,197	37.6	37.20
351	9,100–10,000	9,400	3,418	36.3	35.72
99	10,100–11,000	10,400	3,627	34.8	34.37
34	11,100–12,000	11,500	3,698	32.1	33.15
7	12,100–13,000	12,300	3,657	29.7	31.53
1	----------------	13,200	4,300	32.5	30.05
1	----------------	14,300	3,500	(a)	------------
1	----------------	16,100	4,100	(a)	------------
1	----------------	18,500	4,200	(a)	------------
2,600	Mean------	8,000	3,064	------------	------------

[a] Not included in the mathematical calculation of the standard.

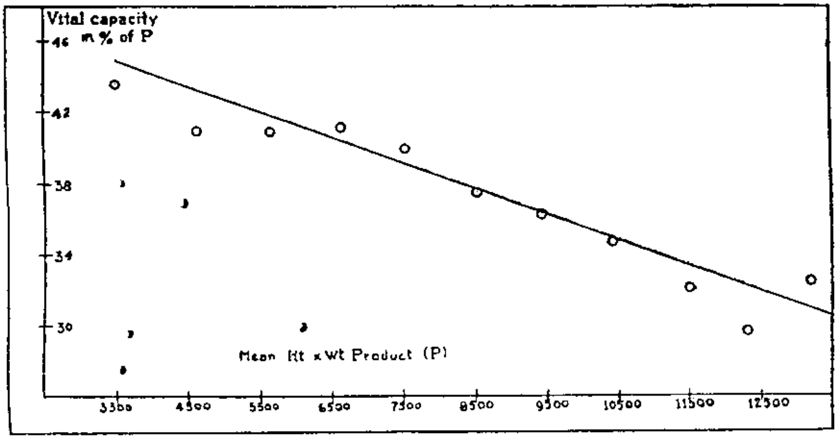

FIG. 2. The relation between the product (P), obtained by multiplying the height in centimeters by the weight in kilograms, and the vital capacity expressed in percentage of this product (per cent of P).

In the fifth column of this table vital capacity is expressed as percentage of P. In fig. 2 vital capacity, as percentage of P, is plotted against P. There is noted a roughly linear tendency to decreasing percentage as P increases. Here again the formula $y = a + bx$ has been applied. If y is taken as the V. C. in per cent of P, and x, as $\frac{P}{1000}$, then $a = 49.0$ and $b = 1.35$. Whence V. C. in per cent of $P = 49 - \frac{1.35\,P}{1000}$. Therefore, V. C. in $cc = \frac{P}{100}\,49 - \frac{1.35\,P}{1000}$.

When the height in centimeters and the weight in kilograms are known, the vital capacity may be readily predicted. For instance, the vital capacity of a man 163 centimeters high and weighing 49 kilograms may be determined as follows: $P = 49 \times 163 = 7{,}987$.

Substituting in the formula

$$\begin{aligned} V.C. &= 79.87\ (49 - 1.35 \times 7.987) \\ &= 79.87\ (49 - 10.78245) \\ &= 79.87 \times 38.21755 \\ &= 3{,}052.4357185 \text{ cubic centimeters.} \end{aligned}$$

In practice 10 cubic centimeters, more or less, of vital capacity is of no account. Hence, to make the calculation simpler it is advisable to cut the decimal places to one before starting any multiplication, exception being made of the constant 1.35.

Thus, the above calculation becomes

$$\begin{aligned} \text{V. C.} &= 79.9\ (49 - 1.35 \times 8.0) \\ &= 79.9\ (49 - 10.8) \\ &= 79.9 \times 38.2 \\ &= 3{,}052.18 \end{aligned}$$

For convenience in routine examinations, Table 3 has been prepared to save time and effort.

THE AGE FACTOR

In compiling our data according to the height and weight arrangement we found different ages represented. It is natural to inquire whether the age factor will have to be reckoned with in applying these tables; in other words, whether in individuals of the same Ht × Wt product the vital capacity will vary with age. In Table 4 are given all the cases under $P = 8{,}500 - 8{,}600$ as an illustration. The cases are arranged according to increasing age. The vital capacities exhibit neither an upward nor a downward trend. Most of the other groups under the different Ht × Wt products likewise showed lack of any definite trend. In a few groups vital capacity seemed to increase with increasing age and in about an equal number of groups the vital capacity decreased with increasing age. We are led to conclude that in the age range of 15 to 30 years here represented the age factor is negligible. Bowen and Platt(4) analyzed one hundred eighty-five men and women varying in age from 15 to 85 years, reducing the vital capacities in terms of cubic centimeter per square meter of body surface. They found that up to 30 years of age no change in vital capacity occurred, and that from that age upwards a gradual decline

TABLE 4.—*Age and vital capacity for* $P = 8{,}500 - 8{,}600$

Number of cases.	Age.	Average vital capacity.	Number of cases.	Age.	Average vital capacity.
	Yrs.			*Yrs.*	
5	15	3,100	5	23	3,340
8	18	3,387	5	24	3,520
13	19	3,169	1	25	3,000
11	20	3,299	2	27	2,800
15	21	3,186	2	29	3,450
10	22	3,229			

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$\frac{P}{100}(49 - 1.35 \frac{P}{100})$ v

Weight.		Height in centimete											
		158	159	169	170	171	172	173	174	175	176	177	178
Kg.													
35	2	------	------	------	------	------	------	------	------	------	------	------	------
36	2	------	------	------	------	------	------	------	------	------	------	------	------
37	2	------	------	------	------	------	------	------	------	------	------	------	------
38	2	------	------	------	------	------	------	------	------	------	------	------	------
39	2	------	------	------	------	------	------	------	------	------	------	------	------
40	2	------	------	------	------	------	------	------	------	------	------	------	------
41	--	------	------	------	------	------	------	------	------	------	------	------	------
42	--	------	------	------	------	------	------	------	------	------	------	------	------
43	--	2,706	------	------	------	------	------	------	------	------	------	------	------
44	--	2,754	2,768	------	------	------	------	------	------	------	------	------	------
45	--	2,801	2,815	2,8	------	------	------	------	------	------	------	------	------
46	--	2,848	2,862	2,8	------	------	------	------	------	------	------	------	------
47	--	2,894	2,908	2,9	------	------	------	------	------	------	------	------	------
48	--	2,940	2,954	2,9	------	------	------	------	------	------	------	------	------
49	--	2,985	2,998	3,0	------	------	------	------	------	------	------	------	------
50	--	3,028	3,042	3,0	------	------	------	------	------	------	------	------	------
51	--	3,072	3,085	3,0	------	------	------	------	------	------	------	------	------
52	--	3,115	3,129	3,1	------	------	------	------	------	------	------	------	------
53	--	3,157	3,170	3,106	------	------	------	------	------	------	------	------	------
54	--	3,198	3,212	3,248	3,361	------	------	------	------	------	------	------	------
55	--	3,239	3,253	3,288	3,402	3,415	3,428	------	------	------	------	------	------
56	--	3,279	3,293	3,328	3,441	3,454	3,467	3,480	------	------	------	------	------
57	--	3,318	3,332	3,368	3,481	3,495	3,508	3,521	3,535	------	------	------	------
58	--	3,357	3,371	3,306	3,519	3,532	3,546	3,559	3,572	3,585	------	------	------
59	--	3,395	3,409	3,444	3,557	3,570	3,584	3,597	3,610	3,623	3,636	3,641	------
60	--	3,432	3,446	3,480	3,593	3,606	3,619	3,632	3,645	3,657	3,670	3,683	3,695
61	--	3,469	3,483	3,417	3,630	3,643	3,655	3,668	3,681	3,694	3,707	3,720	3,733
62	--	3,504	3,518	3,552	3,665	3,678	3,690	3,703	3,716	3,729	3,742	3,754	3,767
63	--	3,540	3,554	3,587	3,699	3,712	3,724	3,737	3,749	3,761	3,773	3,786	3,798
64	--	3,574	3,588	3,621	3,733	3,746	3,758	3,770	3,783	3,795	3,807	3,819	3,832
65	--	3,609	3,622	3,654	3,766	3,778	3,791	3,803	3,815	3,827	3,840	3,852	3,864
66	--	3,641	3,655	3,686	3,798	3,810	3,822	3,835	3,847	3,859	3,871	3,883	3,895
67	--	3,674	3,688	3,717	3,829	3,842	3,854	3,866	3,877	3,889	3,901	3,913	3,924
68	--	3,706	3,719	3,749	3,861	3,872	3,884	3,896	3,908	3,919	3,931	3,942	3,953
69	--	3,737	3,751	3,778	3,890	3,902	3,914	3,926	3,937	3,949	3,960	3,971	3,982
70	--	3,768	3,781	3,707	3,919	3,931	3,943	3,954	3,966	3,977	3,988	3,999	4,010
71	--	3,798	3,811	3,836	3,948	3,959	3,970	3,982	3,993	4,004	4,015	4,025	4,036
72	--	3,827	3,841	3,863	3,975	3,987	3,998	4,009	4,020	4,031	4,042	4,053	4,063
73	--	3,856	3,869	3,891	4,002	4,013	4,024	4,035	4,046	4,057	4,068	4,078	4,088
74	--	3,884	3,897	3,917	4,028	4,039	4,050	4,061	4,071	4,082	4,092	4,102	4,112

TABLE 3.—*Vital-capacity prediction table for male Filipinos 15 to 30 years of age.*

[In accordance with the formula V. C. = $\frac{P}{100}(49 - 1.35\frac{P}{100})$ where P = height (cm) × weight (kg).]

Weight.	Height in centimeters.																																						
Kg.	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178
35	2,077	2,089	2,102	2,114	2,127	2,139	2,151	2,163	2,176	2,188	2,200	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
36	2,127	2,140	2,152	2,165	2,177	2,190	2,202	2,215	2,228	2,240	2,252	2,265	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
37	2,176	2,189	2,202	2,215	2,228	2,240	2,253	2,266	2,279	2,291	2,304	2,316	2,329	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
38	2,225	2,238	2,251	2,264	2,277	2,290	2,303	2,316	2,329	2,342	2,354	2,367	2,380	2,392	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
39	2,273	2,286	2,299	2,313	2,326	2,339	2,352	2,365	2,379	2,392	2,404	2,417	2,430	2,443	2,456	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
40	2,321	2,334	2,348	2,361	2,374	2,388	2,401	2,414	2,428	2,441	2,454	2,467	2,480	2,493	2,506	2,519	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
41	------	2,381	2,395	2,409	2,422	2,436	2,449	2,462	2,476	2,489	2,503	2,516	2,530	2,543	2,556	2,569	2,582	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
42	------	2,429	2,442	2,456	2,470	2,484	2,497	2,511	2,524	2,538	2,551	2,565	2,578	2,591	2,605	2,618	2,631	2,641	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
43	------	2,474	2,489	2,503	2,516	2,530	2,544	2,558	2,572	2,585	2,599	2,612	2,626	2,639	2,653	2,666	2,680	2,693	2,706	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
44	------	2,520	2,535	2,549	2,563	2,577	2,591	2,605	2,618	2,632	2,646	2,660	2,673	2,687	2,700	2,714	2,727	2,740	2,751	2,768	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
45	------	2,565	2,580	2,594	2,608	2,622	2,637	2,651	2,665	2,679	2,693	2,706	2,720	2,734	2,747	2,761	2,774	2,788	2,801	2,815	2,828	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
46	------	------	2,625	2,639	2,654	2,668	2,682	2,696	2,710	2,724	2,738	2,752	2,766	2,780	2,794	2,807	2,821	2,835	2,848	2,862	2,875	2,888	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
47	------	------	2,669	2,684	2,698	2,712	2,727	2,741	2,755	2,770	2,784	2,798	2,812	2,826	2,840	2,854	2,867	2,881	2,894	2,908	2,922	2,935	2,948	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
48	------	------	2,713	2,727	2,742	2,756	2,771	2,785	2,800	2,814	2,828	2,842	2,856	2,870	2,884	2,898	2,912	2,926	2,940	2,954	2,967	2,981	2,994	3,007	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
49	------	------	2,756	2,771	2,785	2,800	2,814	2,829	2,844	2,858	2,872	2,886	2,901	2,915	2,929	2,943	2,957	2,971	2,985	2,998	3,012	3,025	3,039	3,053	3,066	------	------	------	------	------	------	------	------	------	------	------	------	------	------
50	------	------	------	2,813	2,828	2,843	2,857	2,872	2,887	2,901	2,915	2,930	2,944	2,958	2,972	2,987	3,001	3,014	3,028	3,042	3,056	3,069	3,083	3,097	3,110	3,123	3,137	------	------	------	------	------	------	------	------	------	------	------	------
51	------	------	------	2,855	2,870	2,885	2,900	2,915	2,929	2,944	2,958	2,973	2,987	3,002	3,016	3,030	3,044	3,058	3,072	3,085	3,099	3,114	3,127	3,141	3,154	3,167	3,181	3,195	------	------	------	------	------	------	------	------	------	------	------
52	------	------	------	2,897	2,912	2,927	2,942	2,957	2,971	2,986	3,001	3,015	3,030	3,044	3,058	3,072	3,087	3,101	3,115	3,129	3,142	3,156	3,170	3,184	3,197	3,211	3,224	3,237	3,251	------	------	------	------	------	------	------	------	------	------
53	------	------	------	------	2,954	2,969	2,983	2,998	3,013	3,028	3,042	3,057	3,071	3,085	3,100	3,114	3,129	3,143	3,157	3,170	3,184	3,198	3,211	3,225	3,239	3,252	3,266	3,279	3,293	3,306	------	------	------	------	------	------	------	------	------
54	------	------	------	------	2,994	3,009	3,024	3,039	3,054	3,069	3,083	3,098	3,112	3,127	3,142	3,156	3,170	3,184	3,198	3,212	3,226	3,239	3,253	3,267	3,280	3,294	3,308	3,321	3,334	3,348	3,361	------	------	------	------	------	------	------	------
55	------	------	------	------	------	3,049	3,064	3,079	3,094	3,109	3,123	3,138	3,153	3,167	3,182	3,196	3,211	3,225	3,239	3,253	3,267	3,281	3,294	3,308	3,321	3,335	3,348	3,362	3,375	3,388	3,402	3,415	3,428	------	------	------	------	------	------
56	------	------	------	------	------	3,089	3,104	3,119	3,134	3,149	3,163	3,178	3,193	3,207	3,222	3,236	3,251	3,265	3,279	3,293	3,307	3,321	3,334	3,348	3,361	3,375	3,388	3,401	3,415	3,428	3,441	3,454	3,467	3,480	------	------	------	------	------
57	------	------	------	------	------	------	3,143	3,158	3,173	3,188	3,203	3,217	3,232	3,247	3,261	3,275	3,290	3,304	3,318	3,332	3,346	3,360	3,373	3,387	3,401	3,414	3,428	3,441	3,445	3,468	3,481	3,495	3,508	3,521	3,535	------	------	------	------
58	------	------	------	------	------	------	3,181	3,196	3,211	3,226	3,241	3,256	3,271	3,285	3,299	3,314	3,329	3,343	3,357	3,371	3,385	3,399	3,413	3,426	3,440	3,453	3,466	3,479	3,493	3,506	3,519	3,532	3,546	3,559	3,572	3,585	------	------	------
59	------	------	------	------	------	------	------	3,234	3,249	3,264	3,279	3,294	3,308	3,323	3,337	3,352	3,366	3,380	3,395	3,409	3,423	3,437	3,450	3,464	3,478	3,491	3,504	3,518	3,531	3,544	3,557	3,570	3,584	3,597	3,610	3,623	3,636	3,641	------
60	------	------	------	------	------	------	------	3,271	3,286	3,301	3,316	3,331	3,346	3,361	3,375	3,389	3,403	3,418	3,432	3,446	3,460	3,474	3,488	3,501	3,515	3,528	3,541	3,554	3,567	3,580	3,593	3,606	3,619	3,632	3,645	3,657	3,670	3,683	3,695
61	------	------	------	------	------	------	------	------	3,323	3,338	3,353	3,368	3,382	3,397	3,412	3,426	3,440	3,454	3,469	3,483	3,496	3,510	3,524	3,538	3,551	3,564	3,578	3,591	3,604	3,617	3,630	3,643	3,655	3,668	3,681	3,694	3,707	3,720	3,733
62	------	------	------	------	------	------	------	------	3,359	3,374	3,389	3,404	3,419	3,433	3,448	3,462	3,476	3,490	3,504	3,518	3,532	3,546	3,560	3,573	3,586	3,600	3,613	3,626	3,639	3,652	3,665	3,678	3,690	3,703	3,716	3,729	3,742	3,754	3,767
63	------	------	------	------	------	------	------	------	------	3,410	3,425	3,440	3,454	3,469	3,483	3,498	3,512	3,526	3,540	3,554	3,568	3,582	3,595	3,608	3,621	3,635	3,648	3,661	3,674	3,687	3,699	3,712	3,724	3,737	3,749	3,761	3,773	3,786	3,798
64	------	------	------	------	------	------	------	------	------	3,445	3,460	3,474	3,489	3,503	3,517	3,532	3,546	3,560	3,574	3,588	3,602	3,616	3,629	3,643	3,656	3,669	3,682	3,695	3,708	3,721	3,733	3,746	3,758	3,770	3,783	3,795	3,807	3,819	3,832
65	------	------	------	------	------	------	------	------	------	------	3,494	3,509	3,524	3,538	3,553	3,567	3,581	3,595	3,609	3,622	3,636	3,649	3,662	3,676	3,689	3,702	3,715	3,728	3,741	3,754	3,766	3,778	3,791	3,803	3,815	3,827	3,840	3,852	3,864
66	------	------	------	------	------	------	------	------	------	------	3,527	3,542	3,557	3,572	3,586	3,600	3,614	3,628	3,641	3,655	3,669	3,682	3,696	3,709	3,722	3,735	3,748	3,761	3,773	3,786	3,798	3,810	3,822	3,835	3,847	3,859	3,871	3,883	3,895
67	------	------	------	------	------	------	------	------	------	------	------	3,575	3,590	3,604	3,619	3,633	3,647	3,661	3,674	3,688	3,702	3,715	3,728	3,742	3,755	3,768	3,780	3,792	3,805	3,817	3,829	3,842	3,854	3,866	3,877	3,889	3,901	3,913	3,924
68	------	------	------	------	------	------	------	------	------	------	------	3,608	3,622	3,636	3,650	3,664	3,678	3,692	3,706	3,719	3,733	3,746	3,760	3,773	3,785	3,798	3,811	3,824	3,836	3,849	3,861	3,872	3,884	3,896	3,908	3,919	3,931	3,942	3,953
69	------	------	------	------	------	------	------	------	------	------	------	------	3,654	3,668	3,682	3,696	3,710	3,724	3,737	3,751	3,765	3,778	3,791	3,804	3,816	3,829	3,842	3,854	3,866	3,878	3,890	3,902	3,914	3,926	3,937	3,949	3,960	3,971	3,982
70	------	------	------	------	------	------	------	------	------	------	------	------	3,686	3,700	3,714	3,727	3,741	3,754	3,768	3,781	3,795	3,808	3,821	3,834	3,846	3,859	3,871	3,883	3,895	3,907	3,919	3,931	3,943	3,954	3,966	3,977	3,988	3,999	4,010
71	------	------	------	------	------	------	------	------	------	------	------	------	------	3,729	3,743	3,757	3,771	3,784	3,798	3,811	3,824	3,837	3,850	3,863	3,875	3,887	3,900	3,912	3,924	3,936	3,948	3,959	3,970	3,982	3,993	4,004	4,015	4,025	4,036
72	------	------	------	------	------	------	------	------	------	------	------	------	------	3,759	3,773	3,787	3,801	3,814	3,827	3,841	3,853	3,866	3,878	3,891	3,904	3,916	3,928	3,940	3,952	3,963	3,975	3,987	3,998	4,009	4,020	4,031	4,042	4,053	4,063
73	------	------	------	------	------	------	------	------	------	------	------	------	------	------	3,802	3,815	3,829	3,843	3,856	3,869	3,881	3,894	3,906	3,919	3,932	3,944	3,955	3,967	3,979	3,991	4,002	4,013	4,024	4,035	4,046	4,057	4,068	4,078	4,088
74	------	------	------	------	------	------	------	------	------	------	------	------	------	------	3,831	3,845	3,858	3,871	3,884	3,897	3,910	3,922	3,934	3,949	3,959	3,971	3,982	3,994	4,006	4,017	4,028	4,039	4,050	4,061	4,071	4,082	4,092	4,102	4,112

in vital capacity was distinctly manifest. In our present series, therefore, we may disregard the age factor.

VALIDITY OF OUR PREDICTION STANDARD

As has been stated before, the standard based on body surface area is conceded to be the best for vital-capacity work so far devised. Therefore, although we feel that it is not proper to apply the Dubois formula, developed from American subjects, to our series, we felt that it would be interesting to see how our formula would compare with the body-surface standard when the latter is applied to Filipinos. In using the body-surface-area standard it is necessary to determine the average number of liters of vital capacity per square meter of body surface, in other words, the constant. In our series this constant is 2.004, or practically 2. The formula for our series according to the body-surface-area standard is, therefore, V. C. in liters $= 2A$, where A is the body-surface area in square meters.

TABLE 5.—*Frequency distribution of vital-capacity values according to three standards.*

Basis of standard.	Less than 80 per cent of the standard.	80 to 89 per cent of the standard.	90 to 109 per cent of the standard.	110 to 119 per cent of the standard.	Greater than 120 per cent of the standard.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Height	5	13	54	19	9
Ht × Wt	5	14	63	14	4
Body surface	4	12	60	18	6

The percentage distribution of the Filipino cases according to the standards already discussed is given in Table 5 and presented graphically in fig. 3. One sees at a glance that the standard based on our formula is better than that based on body-surface area as applied to the Filipinos.

A comparison was next made between the body-surface formula and ours when applied to American subjects. For this purpose the data of West(5) for men were utilized. Our formula as developed for the American series is $V.\ C. = \frac{P}{100}\left(52.7 - \frac{P}{1{,}000}\right)$. The body-surface formula as applied by West to the same series is $V.\ C. = 2.5\ A$. The percentage distribution of the cases in this American series according to the two

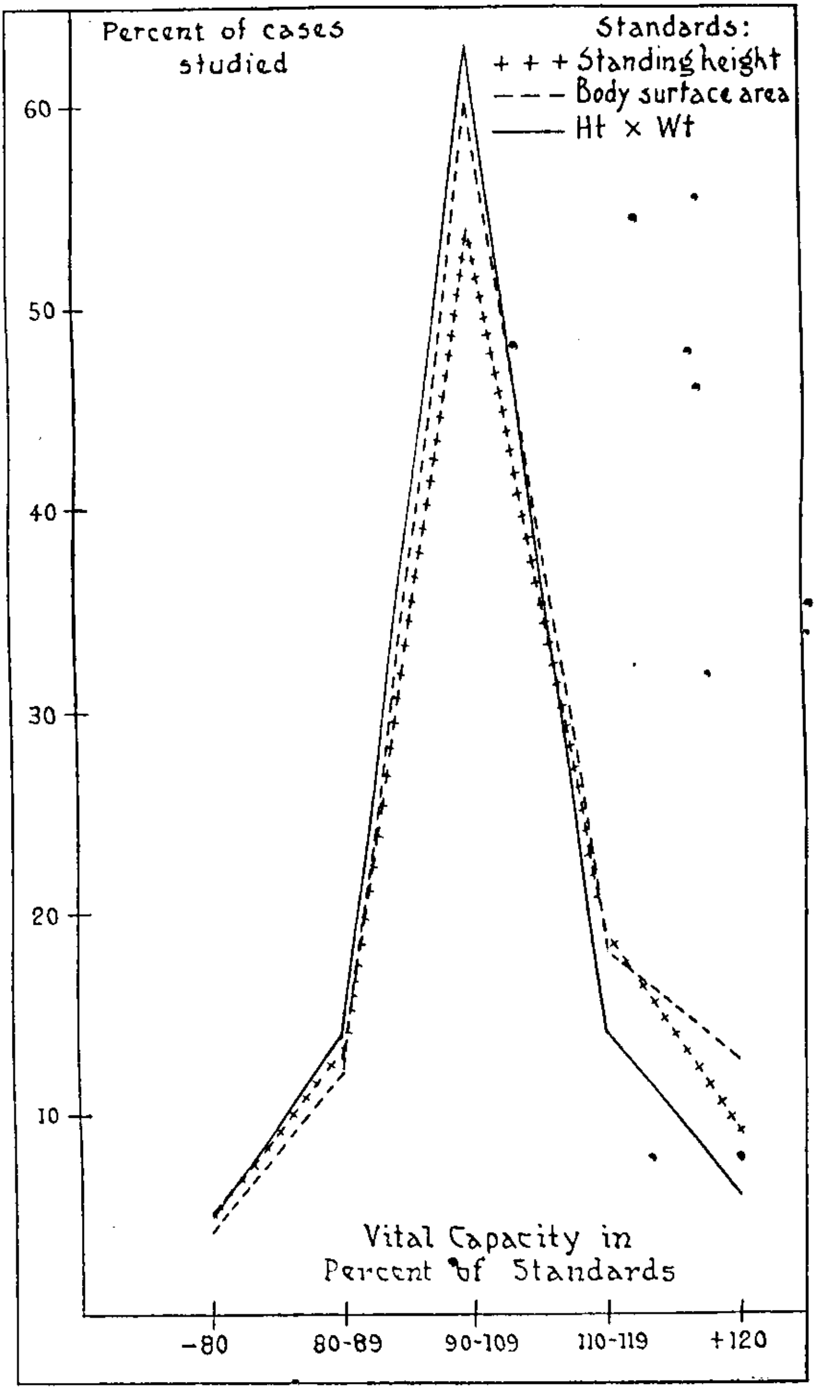

FIG. 3. Percentage distribution of the cases according to three standards.

formulæ is given in Table 6. Even here, our formula seems to give better correlations than the body-surface standard.

TABLE 6.—*Percentage distribution of West's 85 male Americans according to the Ht × Wt (P) and the body-surface standards.*

Basis of standard.	Less than 80 per cent of the standard.	80 to 89 per cent of the standard.	90 to 109 per cent of the standard.	110 to 119 per cent of the standard.	Greater than 120 per cent of the standard.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Body surface	----------	5.9	67.0	22.4	4.7
Ht × Wt (P)	1.2	10.6	74.1	14.1	----------

As may be seen, our formula is developed by a direct statistical study of the height and weight data on a large series of subjects. The body-surface standard is based on two separate statistical studies; one on body-surface area, and the other on vital capacity in relation to body surface. In the latter instance, vital capacity is also correlated with the height and weight but through the intermediation of a statistically determined height-weight formula. It is very probable that the better correlation shown by our formula is not merely accidental. It would be interesting to have it tried out further among American and European subjects.

COMMENTS

The variation in vital capacity from individual to individual is so great even among those of apparently the same general physical condition that it is customary to employ all known standards in determining doubtful cases. It should be borne in mind that most if not all conditions tending to increase vital capacity above normal are favorable for good health, and most of the causes of its reduction are not favorable. From a medical standpoint, therefore, we are interested mostly in persons who fall below the normal average. As has been stated before, all our subjects appeared normal from a routine medical examination. However, most of those whose vital capacities were lower than 80 per cent of the normal were rather below par in physical development. Individuals of this type, constituting 5 per cent of our series, should put us on guard, and they should be carefully examined for possible conditions that may need medical attention. No categorical statement can be made as to what vital capacity is normal and what is abnormal. We have on record a member of our own staff whose vital capacity is about 37 per cent below normal by the different standards, yet he is in a healthier condition than many whose vital capacities are up to standard.

Vital-capacity determinations, though of wide application in medical examinations in America and Europe, are hardly used in this country owing to the lack of standards for the interpretation of the findings. Nañagas(6) and Concepcion(7), independently, studied the vital capacity of Filipinos, but limited themselves to the determination of general averages only. We confirm the findings of the latter to the effect that the mean vital capacity of male Filipinos is about 3,000 cubic centimeters, and is much lower than the American and European average. This diminution may be expected in view of the generally smaller size of Filipinos. But the lowering of vital capacity does not seem to be a decrease merely because of the smaller size. Thus, our men give an average vital capacity of 2 liters per square meter of body surface, equivalent only to the average vital capacity of American women. The American men give 2.5 liters per square meter of body surface. Even thus reduced to as near a common denominator as possible, our people give a proportionately much less vital capacity than Americans and Europeans. It is only pertinent to mention here that among Chinese men(8) the vital capacity expressed in liters per square meter of body surface is also 2, which is of the same order of magnitude as ours. It is not within the scope of this work to discuss all the factors that may affect vital capacity, much less to seek an explanation for the lower figures found for our people.

SUMMARY

1. The vital capacities of 2,600 male university students from 15 to 30 years of age are analyzed, and two prediction standards are prepared; one is based on standing height, and the other is based on the product obtained by multiplying the height in centimeters by the weight in kilograms.

2. The Ht × Wt standard is considered the better of the two. It is also shown that this standard is better than the surface-area standard when applied both to Filipino and American men.

3. The average vital capacity of Filipinos, expressed in liters per square meter of body surface, is 2, the same as that of male Chinese, lower than that of American men (2.5), and equivalent only to the vital capacity of American women.

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ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Chart showing vital capacity in relation to standing height.
2. Chart showing the relation between the product (P) obtained by multiplying the height in centimeters by the weight in kilograms and the vital capacity expressed in percentage of this product (per cent of P).
3. Chart showing percentage distribution of the cases according to three standards.

NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), IX[1]

By CHARLES P. ALEXANDER
Of Amherst, Massachusetts

TWO PLATES

The crane flies discussed herein are chiefly from Szechwan Province, western China, where two important lots of material are included, one from Mount Omei, collected by a Canadian missionary and received through the kind interest of my friend Mr. Herbert S. Parish, the second collected by Reverend David C. Graham and now preserved in the United States National Museum. An exceptionally interesting series of crane flies taken in the Japanese Alps, on and near Mount Norikura, were sent to me by Prof. Jiro Machida, to whom I express my deep thanks for continued coöperation in making known the rich tipulid fauna of the Japanese mountains. One further species from Formosa was included in rich collections taken by my friend, Prof. Syuti Issiki. Except where noted to the contrary, the types of the species here discussed are preserved in my collection.

The following records of species taken in July, 1929, on and near Norikuradake, Shinano, Japan, by Prof. Jiro Machida, are of interest.

Norikuradake, July 26, 1929 (*J. Machida*).

Tipula depressa sp. nov.
Tipula kuzuensis Alex.
Tipula nippoalpina sp. nov.
Tipula politostriata sp. nov.
Tipula sachalinensis Alex.
Tipula uenoi Alex.
Nephrotoma saghaliensis Alex.
Cylindrotoma japonica Alex.
Phalacrocera megacauda sp. nov.
Limonia (*Limonia*) *machidai* (Alex.).
Dicranoptycha cæsia pallidibasis subsp. nov.
Tricyphona pectinata sp. nov.
Tricyphona seticauda sp. nov.
Heterangæus laticincta sp. nov.
Limnophila (*Tricholimnophila*) *saitamæ* Alex.
Limnophila mundella sp. nov.
Molophilus ferox sp. nov.

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[1] Contribution from the Department of Entomology, Massachusetts Agricultural College.

Shirahone Hot Springs, near Norikuradake, July 25, 1929 (J. Machida).

Tipula bubo Alex.

Gnophomyia tristis Alex.

Hirayu, Norikuradake, July 27, 1929 (J. Machida).

Tipula matsumuriana Alex.

Tipula politostriata sp. nov.

Nephrotoma saghaliensis Alex.

Limonia (Limonia) subnubeculosa (Alex.).

Heterangæus laticincta sp. nov.

Limnophila (Ephelia) dietziana Alex.

Erioptera (Ilisia) machidai sp. nov.

TIPULINÆ

DOLICHOPEZA (NESOPEZA) SUBGENICULATA sp. nov.

Closely allied to *D. (N.) geniculata* (Alexander) but details of male hypopygium quite distinct; outer dististyle slender, constricted and bent at near midlength; lateral portions of ninth sternite strongly produced caudad.

Male.—Length, about 6.5 millimeters; wing, 8.

Female.—Length, about 8 millimeters; wing, 9.

Antennal flagellum yellow, the outer segments darkened.

Mesonotal præscutum brown with four darker brown stripes that are little evident against the ground color; scutellum and postnotal mediotergite more testaceous. Pleura chiefly dark brown, the dorsopleural region and pteropleurite abruptly pale. Halteres yellow, the knobs blackened. Legs with the fore coxæ brownish black, the remaining coxæ pale; trochanters yellow; femoral tips broadly blackened, the tibial bases narrowly whitened, the tips more broadly blackened; both femora and tibiæ with a more whitish subterminal ring; tarsi white. Wings with the pattern as in *geniculata;* ground color gray, the costal margin with four brown areas, the largest basal, the third along the cord to M, the fourth apical, interrupted by hyaline droplets in outer ends of cells R_3 and R_5; a more whitish border delimiting the brown costal border behind; no conspicuous darkening caudad of the main costal pattern excepting a small cloud at end of Cu_1. Venation: Medial forks short.

Abdomen dark brown, the tergites variegated with gray areas on lateral margins of basal rings; outer sternites more blackened. Male hypopygium with the caudal margin of the ninth tergite (Plate 2, fig. 21) trilobed, the median lobe shortest, obtuse. Outer dististyle (Plate 2, fig. 22) slender, strongly constricted and strongly bent at just beyond midlength. Inner dististyle (Plate 2, fig. 23) broad, near base on outer face with several strong setæ, in addition to the usual more delicate ones. Lateral lobes of ninth sternite strongly developed, stouter than in *oberon*.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 4,500 feet, July 31, 1929 (ex Parish). Allotopotype, female, August 14, 1929.

Very closely related to *D.* (*N.*) *geniculata* of Japan, differing especially in the structure of the male hypopygium. The production of the lobes of the ninth sternite is much as in *D.* (*N.*) *oberon* (Alexander) of Luzon, but the other features of the hypopygium are distinct.

TIPULA EXUSTA sp. nov.

Belongs to the *cinereifrons* group; thorax and abdomen entirely reddish orange; head gray; antennæ and legs black; R_{1+2} atrophied; male hypopygium with only a single complicated dististyle.

Male.—Length, about 12 millimeters; wing, 11.

Frontal prolongation of head gray, the nasus short and stout; palpi black. Antennæ (male) of moderate length, if bent backward scarcely attaining the wing root; black, the second scapal segment a little paler apically; flagellar segments only slightly enlarged basally. Head dark gray.

Thorax entirely reddish orange, without markings. Halteres pale, the knobs dark brown. Legs with the coxæ and trochanters orange; legs black, the femora narrowly obscure yellow at base. Wings (Plate 1, fig. 1) gray, the stigma brown; obliterative areas very restricted; veins black. Venation: R_{1+2} entirely atrophied; cell 1st M_2 long-pentagonal; petiole of cell M_1 about one-half the cell; cell 2d A relatively wide.

Abdomen, including the hypopygium, reddish orange. Male hypopygium (Plate 2, fig. 24) with the tergite (Plate 2, fig. 25) pale, the caudal margin with a broad, shallow, V-shaped notch, the margins medially narrowly blackened, beneath further produced on either side of the median line into a smooth flattened black plate that is directed caudad and slightly ventrad, the margin obtuse. Basistyle produced caudad into a small obtuse lobule. A single complex flattened dististyle (Plate 2, fig. 26) shaped as in the figure. Notch of the ninth sternite relatively shallow, with a small more or less bifid fleshy lobe jutting caudad, placed close to the suture of the basistyle. Eighth sternite, 8*s*, unarmed.

Habitat.—China (Szechwan).

Holotype, male, Mupin, altitude 3,500 feet, June 30, 1929 (*D. C. Graham*). Type in the collection of the United States National Museum.

Tipula exusta is distinct from regional small species of the *cinereifrons* group in the structure of the male hypopygium.

TIPULA NIPPOALPINA sp. nov.

General coloration gray; nasus lacking; head with a median brown vitta; præscutum with four brown stripes; legs reddish, the tips of the femora and tibiæ narrowly blackened; wings whitish yellow, with a gray and brown clouded pattern; R_{2+3} in direct alignment with the straight R_3; abdomen reddish yellow, segments five to nine black; male hypopygium with the tergite with a U-shaped median notch, and having a smaller quadrate median incision at its base; eighth sternite unarmed.

Male.—Length, about 15 millimeters; wing, 15.5.

Frontal prolongation of head black, sparsely pruinose; nasus lacking; palpi black. Antennæ with the scapal segments and all but the extreme apex of the first flagellar segment reddish yellow; remainder of antennæ black; flagellar segments moderately incised, the longest verticils a trifle shorter than the segments. Head gray, with a pale brown median vitta.

Mesonotal præscutum gray, with four scarcely indicated brown stripes, the intermediate pair obsolete on anterior portions; scutum gray, the lobes very slightly darkened; scutellum and postnotum gray with a nearly continuous median darker vitta. Pleura gray, the dorsopleural region more buffy. Halteres pale, the knobs infuscated. Legs with the coxæ brownish gray; trochanters reddish; femora and tibiæ reddish yellow, the tips narrowly but conspicuously blackened; tarsi passing into black. Wings (Plate 1, fig. 2) with the ground color whitish yellow, the base and costal region clearer yellow; a handsome clouded brown and gray pattern; the ground color includes areas before and beyond the stigma; at beyond midlength of cell R; an oblique area beyond the cord, extending from costa into cell R_5 and a second area extending from the outer end of cell R obliquely across cell 1st M_2 almost to the margin in cell M_4; other pale areas in bases of cubital and anal cells. Venation: Rs long; R_{1+2} subobsolete on outer half; R_2 elongate; R_{2+3} in alignment with the straight R_3.

Abdomen reddish yellow, the basal tergite more pruinose; lateral and caudal portions of segments insensibly darkened;

posterior half of fifth, and all succeeding segments, black. Male hypopygium (Plate 2, fig. 27) with the tergite, sternite, and basistyle all distinct. Ninth tergite (Plate 2, fig. 28) moderately chitinized, not heavily blackened, the caudal margin with a U-shaped notch, at the base of which is a smaller quadrate median incision. Outer dististyle a dusky subcylindrical lobe, the apex obtuse. Inner dististyle (Plate 2, fig. 27, *id*) flattened, compressed, the base with two small lobes, the apex bidentate. Ædeagus, *a*, jutting from genital chamber. Ninth sternite, *9s*, with a V-shaped incision that extends to the base of the segment, the surface unarmed with lobes or tufts. Eighth sternite unarmed.

Habitat.—Japan (Honshiu).

Holotype, male, Norikuradake, Japanese Alps, Shinano, July 26, 1929 (*J. Machida*).

Tipula nippoalpina is distinct from all similar regional species in the lack of a nasus, details of venation, and structure of the male hypopygium.

TIPULA DEPRESSA sp. nov.

General coloration light brown, the præscutum with almost concolorous stripes that are narrowly margined with darker brown; wings brown and gray, variegated with extensive cream-colored areas; male hypopygium with the ninth tergite tridentate; eighth sternite with a conspicuous median tonguelike lobe.

Male.—Length, about 12 millimeters; wing, 14. Described from a somewhat teneral type specimen.

Frontal prolongation of head brownish testaceous. Antennæ with the first scapal segment dark brown, the tip and second scapal segment more reddish brown; flagellum apparently almost uniformly infuscated, the basal enlargements of the segments little if any darker. Head brown.

Mesonotal præscutum light brown, the four usual stripes almost concolorous, the intermediate stripes margined laterally with a conspicuous darker brown line, the mesal edge of the lateral stripes similarly darkened; posterior sclerites of mesonotum light brown, the scutellum more testaceous. Pleura light brown, the ventral pleurotergite darker. Halteres pale, the knobs broken. Legs with the coxæ light brown, trochanters yellow; remainder of legs brown, the femoral bases more brightened. Wings relatively broad, the ground color brown or gray, variegated by extensive cream-colored areas, including a broad crossband beyond the stigma and cord; other areas before stigma, at base and outer end of cell M, outer ends of radial cells, as a broad seam along vein 1st A in cells Cu and 1st A and in the anal cells; veins brown, paler in the creamy areas. Venation: R_{1+2} entire but with macrotrichia confined to basal two-thirds; R_3 elongate, gently arcuated and thus not in alignment with R_{2+3}; cell 1st M_2 small, pentagonal.

Abdomen chiefly reddish yellow. Male hypopygium with the caudal margin of the ninth tergite (Plate 2, fig. 29) conspicuously trifid, the lobes blackened; lateral lobes flattened, slightly incurved, the tips truncated, the outer angles a little decurved; median lobe narrowed outwardly, the ventral surface with a median keel that juts caudad slightly beyond the level of the lobe. Outer dististyle (Plate 2, fig. 30) with the stem narrowed, the apex expanded into a setiferous foot-shaped structure. Inner dististyle (Plate 2, fig. 31) of unusual form, being deeply bilobed, the anterior or cephalic portion being separated from the basal lobe by a conspicuous rounded notch. Eighth sternite (Plate 2, fig. 32) with a conspicuous median depressed lobe, this bearing a small lateral lobule or shoulder on either side; the median tonguelike lobe beyond the lateral lobules is provided with abundant setæ that are directed mesad, these becoming progressively smaller and more delicate away from the margin. Gonapophyses (Plate 2, fig. 33) bifid, the outer arms appearing as acute blackened hooks.

Habitat.—Japan (Honshiu).

Holotype, male, teneral, Norikuradake, Japanese Alps, Shinano, July 26, 1929 (*J. Machida*).

The structure of the male hypopygium serves to separate this alpine species from similar forms.

TIPULA POLITOSTRIATA sp. nov.

Allied to *T. shomio* Alexander; mesonotal præscutum and scutum gray, variegated with polished black areas; blackened femoral tips narrow, occupying about the distal fourth of the segment, the amount subequal on all legs; wings yellow, especially the base and costal margin, the dark pattern restricted; male hypopygium with the outer dististyle relatively small.

Male.—Length, about 13.5 to 14 millimeters; wing, 15.

Female.—Length, about 17 to 18 millimeters; wing, 15 to 16.

Frontal prolongation of head black, sparsely pruinose, paler laterally; nasus distinct; palpi black. Antennæ (male) of moderate length, if bent backward extending about to the wing root; scape and basal two flagellar segments yellow; succeeding segments almost uniformly darkened or with the bases a little darker; outer verticils much longer than the ventral pair. Antennæ of female more uniformly pale. Head gray.

Pronotum blackish gray. Mesonotal præscutum gray, the three usual stripes polished black, distinctly separated by lines of the ground color; scutum gray, the centers of the lobes polished black; scutellum brownish black; postnotum black, sparsely pruinose. Pleura gray. Halteres pale, the knobs weakly infuscated. Legs with the coxæ black, pruinose; trochanters yellow; femora yellow, the tips broadly blackened, the amount subequal on all legs, occupying approximately the distal fourth of the segment; tibiæ yellow, the tips blackened; tarsi black, the proximal ends of basitarsi restrictedly pale. Wings yellow, the base and costal region clearer yellow; a restricted brown pattern, including the stigma and a seam on the anterior cord; narrower brown seams on posterior cord and along vein Cu; a triangular dusky area in outer end of cell 1st A; wing apex more or less darkened, in cases leaving a poorly indicated area of the ground color distad of the stigma and cord. Venation: R_{1+2} preserved; petiole of cell M_1 subequal to or shorter than second section of M_{1+2}.

Abdominal tergites yellow, with three nearly entire blackish stripes, the lateral stripes wider than the median one, which is more or less interrupted at the caudal margins of the segments; subterminal segments blackened, this including the entire eighth sternite; sternites pale, with a median black stripe, the outer segments blackened; hypopygium chiefly pale. Male hypopygium with the median lobe of the tergite a nearly circular compressed blade; lateral margins of tergite beneath with a short, slender, blackened point. Outer dististyle (Plate 2, fig. 34) relatively small, the head only slightly dilated. Inner dististyle as figured (Plate 2, fig. 35). Gonapophyses (Plate 2, fig. 36) appearing as bispinous plates.

Habitat.—Japan (Honshiu).

Holotype, male, Norikuradake, Japanese Alps, Shinano, July 26, 1929, (*J. Machida*). Allotype, female, Hirayu, July 27, 1929 (*J. Machida*). Paratopotypes, 3 females; paratypes, 4 males and females, with the allotype.

Tipula politostriata is most closely allied to *T. shomio* Alexander and *T. strix* Alexander, differing especially in the more nearly unicolorous wings, without infuscation in the costal region, in the more narrowly darkened femoral tips, and in the details of structure of the male hypopygium.

TIPULA ANGUSTILIGULA sp. nov.

Belongs to the *continuata* group; antennal flagellum entirely black, the segments with a single well-developed verticil; præscutum yellow with three brown stripes, the median stripe prolonged backward onto the median region of the scutum and scutellum; pleura entirely yellow; tips of femora blackened; male hypopygium with the ninth tergite unblackened, the caudal margin with a broad U-shaped emargination; ninth sternite with a narrow median liguliform lobe.

Male.—Length, about 9.5 millimeters; wing, 10.

Frontal prolongation of head relatively short, light yellow on dorsal half, more infuscated laterally; nasus conspicuous; palpi black. Antennæ with the first scapal segment yellow, the second tinged with green; flagellum entirely black; verticils of flagellar segments reduced to a single long basal bristle on outer face. Head yellow, the vertex with a linear more-darkened area.

Pronotum darkened medially, more yellowish laterally. Mesonotal præscutum yellow with three brown stripes, the median stripe narrowed behind and traversing both the scutum and scutellum; scutal lobes and parascutella darkened; postnotal mediotergite brownish yellow, with a clearer yellow median line. Pleura yellow. Halteres dusky, the knobs yellowish. Legs with the coxæ and trochanters yellow; femora obscure yellow basally, passing into dark brown; tibiæ black, the extreme base a little brightened; tarsi black. Wings with the ground color whitish, the base and prearcular region more yellowish; stigma oval, dark brown; conspicuous brown washes and seams along most of the veins, more extensive in the outer radial field and in cells R and M, the latter diversified by a single area of the ground color at about the distal fifth; veins black, the basal and costal regions light brown or yellowish brown. Venation: Rs relatively short, gently arcuated; R_{1+2} entire; cell M_1 very deep, barely sessile to very short-petiolate; second section of M_{3+4} relatively extensive, subequal to or longer than r-m.

Abdomen yellow, becoming more brownish yellow on the outer segments; subterminal segments more uniformly infuscated. Male hypopygium (Plate 2, fig. 37) with the tergite, 9*t*, extensive, not blackened, the caudal margin with a broadly rounded U-shaped notch (Plate 2, fig. 38); on ventral margin at near midwidth of the lobes with a small blackened point. Outer dististyle a long cylindrical rod, the base thicker, the surface with long conspicuous setæ. Inner dististyle with the apex simple. Median notch of the ninth sternite at base with a slender pale lobe (Plate 2, fig. 39), slightly broader at base, gradually narrowed to the blunt tip.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 4,500 feet, August 10, 1929 (ex. Parish).

Tipula angustiligula is closest to *T. xanthopleura* Edwards (Tibet to Sikkim); it differs in numerous details, as the entirely blackened antennal flagellum and structure of the male hypopygium, especially the emargination of the tergite and the elongate liguliform lobe of the ninth sternite.

TIPULA LATIFLAVA sp. nov.

Belongs to the *mutila* group; general coloration gray, the præscutum with four broken brown stripes, the interspaces with abundant brown setigerous punctures; knobs of halteres infuscated; legs black, all femora with a very broad yellow subterminal ring; wings whitish subhyaline, with a brown pattern that appears as four interrupted crossbands.

Female.—Length, about 15 millimeters; wing, 13.5.

Frontal prolongation of head gray, more blackened laterally; palpi black. Antennæ with the scape and basal four flagellar segments yellow, the remaining segments more bicolorous, the base being darkened, the apex pale. Head gray, the central region of the vertex with a more or less distinct dusky line.

Pronotum gray, with three brown lines. Mesonotal præscutum gray with four broken brown stripes, the intermediate pair entire on front half, becoming broken behind, separated from one another by a capillary brown median vitta; lateral stripes nearly obsolete, best represented by delicate margins; interspaces with abundant brown setigerous punctures; scutum gray, each lobe with two brown areas; scutellum gray, with a faint brown median vitta; postnotal mediotergite gray with a dark brown median line. Pleura yellowish gray, more or less variegated with darker, especially on the ventral sternopleurite and meron. Halteres yellow, the knobs infuscated. Legs with the coxæ gray; trochanters brownish yellow; femora black, with a very broad yellowish ring before the tips, this ring approximately three times the black tip; tibiæ and tarsi black. Wings (Plate 1, fig. 3) relatively narrow, whitish subhyaline, with a brown pattern that is chiefly distributed as four broken crossbands; cell C dark brown; Sc more yellowish brown; the most extensive of the crossbands is that at origin of Rs, becoming wider and more diffuse in the anal cells; apical band confined to the radial field; narrow brown seams at margin and along veins Cu and 2d A; veins yellow, brown in the clouded areas. Venation: R_{1+2} atrophied; Rs about one-third longer than R_{2+3}; cell 1st M_2 small, irregularly pentagonal, the shortest element being m.

Abdominal tergites obscure brownish yellow, with a conspicuous dorsomedian black stripe that is narrowly interrupted at the caudal margin of each segment; sternites similar, the median stripe broad. Ovipositor with the valves yellowish horn color, the bases of all valves blackened; tergal valves straight and slender.

Habitat.—China (Szechwan).

Holotype, female, Mount Omei, altitude 4,500 feet, August 7, 1929 (ex Parish).

Tipula latiflava is readily told from the two similar regional species, *T. striatipennis* Brunetti and *T. quadrifasciata* Matsumura (*aluco* Alexander), by the unusually broad yellow rings on all femora.

CYLINDROTOMINÆ

CYLINDROTOMA NIGRIPES sp. nov.

General coloration black, the head and thorax more pruinose; dorsopleural region yellow; halteres and legs black; wings with a faint dusky tinge, the small stigma dark brown.

Male?—Length, about 8 millimeters; wings, 9.5.

Mouth parts destroyed. Antennæ short, if bent backward not attaining the wing root; flagellar segments short-cylindrical, the terminal segment longer than the penultimate, pointed at apex; flagellum pale brown, the scapal segments destroyed. Head gray.

Thorax blackened, sparsely gray pruinose, the three præscutal stripes and centers of the scutal lobes more blackened, the interspaces gray pruinose. Pleura black, pruinose, the dorsopleural region conspicuously light yellow; dorsal sternopleurite and ventral pteropleurite a little paler than the remaining pleurites. Halteres blackened. Legs with the coxæ blackish gray, their tips paling to yellow; trochanters obscure yellow; remainder of legs black, only the femoral bases restrictedly obscure yellow. Wings (Plate 1, fig. 4) with a faint dusky tinge, the small oval stigma dark brown; veins dark brown. Venation: Rs long, gently angulated at origin; cell M_1 short-petiolate; m-cu at about two-fifths the lower face of the large cell 1st M_2; cell 2d A relatively narrow.

Abdomen, including the hypopygium, black.

Habitat.—China (Szechwan).

Holotype, sex male?, Mupin, altitude 3,500 feet, June 30, 1929 (*D. C. Graham*). Type in the collection of the United States National Museum.

The antennæ are detached and the tip of the abdomen so crushed that only fragments remain but the sex certainly seems to be male. The black coloration and unusually short antennæ well suffice to distinguish the present species from other known members of the genus.

PHALACROCERA MEGACAUDA sp. nov.

General coloration pale yellow, the mesonotum and pleura variegated with polished black; wings tinged with yellow, the stigma obsolete; basal section of R_{4+5} longer than m-cu, the latter at near two-fifths the length of cell 1st M_2; male hypopygium unusually large, the basistyles apically produced into black earlike plates.

Male.—Length, about 11 millimeters; wing, 10.5.

Rostrum testaceous; palpi pale, the outer segments darkened. Antennæ pale, the outer segments passing into brown. Head brownish black, the anterior vertex silvery.

Pronotum yellow. Mesonotal præscutum yellow with three nearly confluent polished black stripes, the median stripe broadest in front; lateral stripes crossing the suture onto the scutal lobes; remainder of mesonotum yellow, the posterior margin of the postnotal mediotergite with two confluent black areas. Pleura testaceous yellow, the sternopleurite extensively blackened; a smaller black area on the ventral pleurotergite. Halteres chiefly pale. Legs with the coxæ and trochanters yellow; femora obscure yellow, the tips weakly darkened; tibiæ brownish yellow; tarsi passing into dark brown. Wings (Plate 1, fig. 5) tinged with yellow, the stigma obsolete; veins brown. Venation: Sc_1 not reaching costa; free tip of Sc_2 nearly perpendicular, the tip obsolete or nearly so; basal section of R_{4+5} longer than m-cu, the latter gently sinuous, placed at near two-fifths the length of cell 1st M_2.

Abdominal tergites light brown, the outer segments more darkened; hypopygium chiefly pale; sternites obscure yellow, the subterminal segments more infuscated. Male hypopygium unusually large for a member of the genus, the basistyles produced into conspicuous black earlike plates that are conspicuously fringed with yellow setæ.

Habitat.—Japan (Honshiu).

Holotype, male, Norikuradake, Japanese Alps, Shinano, July 26, 1929 (*J. Machida*).

Phalacrocera megacauda is generally similar to *P. mikado* Alexander, differing especially in the unusually large male hypopygium.

LIMONIINÆ

LIMONIINI

LIMONIA (DICRANOMYIA) SUBPULCHRIPENNIS sp. nov.

Differs from *L.* (*D.*) *pulchripennis* in the darkened wing apex and complete white subapical crossband; darkened areas of costal field extending caudad to vein M.

Male.—Length, about 6.5 millimeters; wing, 7.5.

Female.—Length, about 9.5 millimeters; wing, 8.5.

Rostrum black, pruinose; palpi black. Antennæ with the scapal segments black, the flagellum yellow, only the outer segments more infuscated; flagellar segments oval, becoming more elongate outwardly, the verticils short. Head black, yellowish gray pruinose.

Pronotum black medially, more grayish pruinose laterally. Mesonotal præscutum with the ground color brownish gray with three black stripes, the median one broad and complete, the lateral stripes remote from the suture; scutal lobes black; median region of scutum and the scutellum more grayish; postnotum black, sparsely pruinose. Pleura heavily gray pruinose, striped longitudinally with a narrow blackish area on the anepisternum. Halteres yellow, the knobs black. Legs with the coxæ and trochanters black, more or less pruinose; femora yellow, the tips broadly black; tibiæ yellow, the bases and tips narrowly blackened; basitarsi brownish yellow, the outer segments blackened. Wings (Plate 1, fig. 6) whitish, with a heavy brown pattern of the general type of *pulchripennis;* areas of costal margin continued back to vein M and only slightly narrowed posteriorly; wing apex uniformly darkened, not interrupted by a pale streak in cell R_5, as is the case in *pulchripennis;* a complete white subterminal crossband. Venation: Cell 1st M_2 open or tending to be open by the atrophy or thinning out of the distal section of M_3 (figured as present, though faint).

Abdomen black, the hypopygium obscure yellow. Male hypopygium with the rostral spine shorter than in *pulchripennis,* appressed to the margin of style.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 4,500 feet, July 31, 1929 (ex Parish). Allotopotype, female.

Closely allied to *pulchripennis* (Brunetti), differing especially in the wing pattern and details of structure of the male hypopygium.

LIMONIA (EUGLOCHINA) DIGNITOSA sp. nov.

General coloration dark brown; tarsi entirely snowy white; wings with Rs long, angulated at origin; inner end of stigma not passing far basad of fork of Rs; Cu_2 present as a distinct element that is equal in length to Sc or 2d A.

Male.—Length, about 7.5 to 8 millimeters; wing, 8 to 9.

Female.—Length, about 7 to 7.5 millimeters; wing, 7 to 8.

Rostrum and palpi brown. Antennæ black, relatively long for a member of the subgenus; flagellar segments long-oval, with a dusky glabrous apical neck; each flagellar segment with one very long verticil, these unilaterally arranged. Head black.

Thorax dark brown. Halteres elongate, testaceous, the knobs dark brown. Legs with the coxæ and trochanters brownish testaceous; femora and tibiæ black; tarsi entirely snowy white. Wings (Plate 1, fig. 7) with a strong brownish tinge, somewhat clearer basally; stigma oval, darker brown; veins brownish black. Venation: Sc relatively long, the distance between the tip of Sc_1 and origin of Rs not exceeding twice Rs; Sc_2 variable in length; Rs long, arcuated or angulated at origin, remote from the inner end of the stigma; cell 1st M_2 closed; Cu_2 present as a distinct element to about opposite the end of veins Sc_1 and 2d A

Abdomen brownish black, the basal sternites paler.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 6,000 feet, July 24, 1929 (ex Parish). Allotopotype, female. Paratopotypes, 1 male, 1 female.

Limonia (*Euglochina*) *dignitosa* is distinct from all known species of the subgenus. The length of Rs and its relation to the proximal end of the stigma is approached by *L.* (*E.*) *okinawensis* (Alexander), which differs in the darkened proximal ends of the basitarsi, the loss of vein Cu_2, and the shorter Sc.

ANTOCHA (ANTOCHA) MINUTICORNIS sp. nov.

General coloration ocherous, the præscutum with four brown stripes; antennæ small; wings grayish white, the stigma lacking;

male hypopygium with the outer dististyle blackened, glabrous, here the apex narrowed to an obtuse point.

Male.—Length, about 4.5 millimeters; wing, 5.2.

Female.—Length, about 5.5 millimeters; wing, 5.6.

Rostrum brownish yellow; palpi brownish black. Antennæ small in both sexes, if bent backward ending some distance before the wing root; basal segments pale, the outer segments passing into dark brown; pubescence and verticils of segments short. Head brownish gray.

Mesonotal præscutum ocherous, with four brown stripes, the approximated intermediate pair darker and better delimited; scutum and postnotum gray, the scutellum more ocherous. Pleura obscure brownish ocherous, more or less variegated with darker. Halteres dirty white. Legs with the coxæ ocherous, the fore coxæ a little darker; trochanters obscure yellow; remainder of legs brownish yellow, the tarsi passing into brown. Wings (Plate 1, fig. 8) grayish white, the costal region more yellowish; no indication of a stigma; veins pale. Anal angle of wing prominent. Venation: Rs of moderate length only; m-cu before fork of M.

Abdominal tergites brown, the sternites and hypopygium yellow; a conspicuous dark brown subterminal ring in male, occupying segments seven and eight. Male hypopygium (Plate 2, fig. 40) with the caudal margin of tergite, 9*t*, very gently emarginate. Outer dististyle, *od*, blackened, glabrous, near apex gradually narrowed to an obtuse point. Inner dististyle, *id*, a little longer, pale, with conspicuous setæ. Ædeagus slender, subtended by several pale blades and points, as figured.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 4,500 feet, August 2, 1929 (ex Parish). Allotopotype, female, in copula with type.

Antocha minuticornis has a hypopygium that suggests *A. indica* Brunetti (Himalayas, western China, Malay States) and *A. satsuma* Alexander (Japan). The species differs from *indica* in the small antennæ of both sexes and from *satsuma* in the immaculate wings and details of the hypopygium.

ANTOCHA (ANTOCHA) NEBULIPENNIS sp. nov.

Size large (wing, male, 8 millimeters); general coloration yellowish gray; wings whitish subhyaline, handsomely clouded with gray; male hypopygium with the caudal margin of tergite with a rounded lobe on either side of a small rounded notch;

basistyle with the outer apical angle produced into an obtuse lobe; outer dististyle blackened and acute at tip.

Male.—Length, about 7 millimeters; wing, 8.

Rostrum and palpi destroyed. Antennæ relatively short, black; flagellar segments oval, with short verticils. Head yellowish gray.

Mesonotum, yellowish gray, crushed in the unique type, the præscutum apparently without stripes. Pleura yellowish gray. Legs with the coxæ brownish gray; legs relatively long, reddish brown, the outer tarsal segments more darkened. Wings (Plate 1, fig. 9) whitish subhyaline, with a clouded gray pattern, including areas in cell R at near midlength of Rs, along cord and outer end of cell 1st M_2; outer end of vein R_3 and as marginal seams along the longitudinal veins beyond the cord; stigma elongate, brownish gray; veins brown, darker in the infuscated areas. Venation: Rs long; inner end of cell R_3 far basad of cell R_5; cell 1st M_2 closed; m-cu shortly before the fork of M.

Abdomen gray. Male hypopygium (Plate 2, fig. 41) with the tergite, *9t*, transverse, the caudal margin with a small rounded lobe on either side of a similarly formed median notch. Basistyle, *b*, with the outer apical angle produced caudad into an obtuse lobe, the dististyles thus subterminal in position. Outer dististyle, *od*, strongly bent before apex, the tip blackened, narrowed into an acute spine. Inner dististyle, *id*, arcuated, the apex more dilated into a weak spatula that is densely set with short curved spinous setæ. Each gonapophysis appearing as a slender yellow rod.

Habitat.—China (Szechwan).

Holotype, male, Mupin, altitude 3,500 feet, June 30, 1929 (*D. C. Graham*). Type in the collection of the United States National Museum.

Antocha nebulipennis is very distinct from regional species in the large size, wing pattern, and structure of the male hypopygium. *Antocha nebulosa* Edwards (Pahang) has a somewhat similarly clouded wing but is a very different fly.

DICRANOPTYCHA CÆSIA PALLIDIBASIS subsp. nov.

Male.—Length, about 7.5 millimeters; wing, 8.5.

Female.—Length, about 9 millimeters; wing, 9.5.

Generally similar to typical *D. cæsia* Alexander, differing as follows:

Scape of antennæ pale. Abdominal tergites dark brown, the basal sternites paler. Male hypopygium with the outer dististyle gently curved, the outer margin with conspicuous appressed serrations, the apical spine smooth. Inner dististyle stout, angularly bent near midlength, the apex subtruncate. Lateral arms of tergite gently curved, the concave margin microscopically serrulate.

Habitat.—Japan (Honshiu).

Holotype, male, Norikuradake, Japanese Alps, Shinano, July 26, 1929 (*J. Machida*). Allotopotype, female.

PEDICIINI

TRICYPHONA PECTINATA sp. nov.

General coloration reddish brown, the præscutum with three ill-defined blackish stripes; wings faintly suffused with brown; cell R_4 petiolate; medial field of wing beyond cord tending to be pectinate by the atrophy of the basal section of M_3.

Male.—Length, about 5.5 to 6 millimeters; wing, 6.5 to 8.

Rostrum and palpi black. Antennæ brown, 15-segmented; basal flagellar segments small and crowded, the outer segments becoming more attenuate. Head gray; anterior vertex wide, with a circular median depression surrounded by an elevated rim.

Pronotum brownish gray. Mesonotum reddish brown, the præscutum with three ill-defined blackish stripes, the lateral stripes barely indicated; scutellum reddish brown. Pleura blackish gray. Halteres pale, the knobs dusky. Legs with the coxæ and trochanters obscure yellow; femora yellow, the tips passing into brown; tibiæ and tarsi brown. Wings (Plate 1, fig. 10) faintly suffused with brown, the stigmal region diffusely darker brown; veins pale brown. Venation: Cell R_4 petiolate, the petiole subequal to r-m; medial field beyond cord tending to be pectinate by the atrophy of the basal section of M_3, in a few cases with cell 1st M_2 closed or with a mere spur of M_3.

Abdomen black, the hypopygium paler. Male hypopygium about as in *T. insulana* Alexander.

Habitat.—Japan (Honshiu).

Holotype, male, Norikuradake, Japanese Alps, Shinano, July 26, 1929 (*J. Machida*). Paratopotypes, 3 males.

Tricyphona pectinata is obviously allied to *T. insulana* Alexander, differing most evidently in the smaller size, brownish body coloration, tinted wings, and the normally pectinate venation of the medial field of the wing.

TRICYPHONA SETIPENNIS sp. nov.

Allied to *T. vetusta* Alexander; general coloration gray, the præscutum with four brown stripes; apical cells of wing, from Sc_1 to 2d M_2, inclusive, with macrotrichia; male hypopygium with the tergite narrowed outwardly, setiferous; mesal lobe of dististyle narrowed outwardly.

Male.—Length, about 9 millimeters; wing, 12.

Rostrum black, a little paler ventrally; palpi black. Antennæ black, the first scapal segment a little paler. Head dark gray, the anterior vertex paler gray.

Pronotum light gray. Mesonotal præscutum gray with four brown stripes, the intermediate pair long, more confluent in front; scutum gray, the lobes more blackened; scutellum and postnotum pale brown, sparsely pruinose. Pleura brown, sparsely pruinose, the ventral sternopleurite darker. Halteres pale, the knobs weakly infuscated. Legs with the coxæ pale, sparsely pruinose; trochanters yellow; femora yellow, passing into brownish black; tibiæ brown, the tips darker; tarsi brownish black. Wings (Plate 1, fig. 11) yellow, with a sparse brown pattern arranged about as in *vetusta.* Sparse macrotrichia in outer ends of cells Sc_1 to 2d M_2, inclusive. Venation: Cell R_3 petiolate, the petiole subperpendicular, in alignment with r-m.

Abdominal tergites light brown, paler laterally; outer segments and hypopygium brownish black. Male hypopygium with the general structure of *T. seticauda* Alexander. Ninth tergite extensive, gradually narrowed outwardly, the surface conspicuously setiferous. Mesal lobe of dististyle narrowed outwardly, the blunt apex with a group of spinous setæ. In *seticauda,* the mesal lobe of the dististyle is a nearly circular flattened disk, its margin evenly rounded.

Habitat.—Japan (Honshiu).

Holotype, male, Norikuradake, Japanese Alps, Shinano, July 26, 1929 (*J. Machida*).

Tricyphona setipennis is most closely related to *T. vetusta* Alexander and *T. seticauda* Alexander, differing most evidently in the macrotrichia in the extreme outer ends of cells Sc_1 to 2d M_2, and the structure of the male hypopygium, especially of the tergite and mesal lobe of the dististyle.

HETERANGÆUS LATICINCTA sp. nov.

Size large (wing over 10 millimeters); antennal flagellum yellow; thoracic pleura with the anepisternum and sternopleurite darkened; legs yellow, the tips of the femora and tibiæ darkened;

wings whitish with a heavy, chiefly cross-banded pattern, including three crossbands; cell C uniformly darkened; cell 2d A wide, the margin crenulate; supernumerary crossveins as in the genus, that in cell R_3 placed far distad, in cell R_4 about in alignment with R_2, in cell M_1 at two-thirds the length of cell.

Male.—Length, about 9.5 millimeters; wing, 10.5.

Female.—Length, about 10 millimeters; wing, 11.5.

Rostrum and palpi black. Antennæ with the basal segment black, the second segment and flagellum yellow. Head gray; vertical tubercle conspicuous.

Pronotum brown, paler laterally. Mesonotal præscutum grayish brown, the humeral region paler; scutellum and postnotum obscure yellow. Pleura yellow, the sternopleurite and anepisternum darker. Halteres of moderate length, yellow, the knobs only weakly darkened. Legs with the coxæ and trochanters pale yellow; femora yellow, the tips broadly and conspicuously dark brown; tibiæ yellowish white, the tips conspicuously blackened, the amount a little less than the femoral tips; tarsi yellow, the tips of segments one to three and all of the remaining segments black. Wings (Plate 1, fig. 12) whitish, with an unusually heavy, chiefly cross-banded pattern, pale yellowish brown, margined with darker brown; cells C and Sc uniformly dark brown, cell Sc_1 variegated with the ground color; the chief fasciæ are those at origin of Rs, including cells R and M; the cord; and a more irregular fascia at the level of the outer end of cell 1st M_2, sending a ray to the apex in cell R_5 and connected with the central fascia in cells R_3 and Cu; fasciæ nearly parallel-sided and unusually wide; a more or less confluent series of spots in cell Cu; a large confluent area in cells 1st A and 2d A, inclosing a circular pale area near the outer end of cell 2d A; veins yellow, darker in the infuscated areas. Wings relatively broad, especially the anal cells; cell 2d A with the margin strongly crenulate to bilobed before the vein. Venation: Rs square and spurred at origin; R_{2+3+4} short, less than the perpendicular basal section of R_{2+3}; supernumerary crossvein in cell R_3 lying far distad, that of cell R_4 nearly in alignment to just beyond the level of R_2, that of cell M_1 lying beyond two-thirds the length of the cell and in alignment with the crossvein in cell R_3; cell 2d A much wider than in *H. japonicus*.

Abdominal tergites brownish black, a little paler laterally; sternites brighter; male hypopygium dark. Male hypopygium almost as in the other species of the genus, the arm of the dististyle unispinous, the ædeagus capitate.

Habitat.—Japan (Honshiu).

Holotype, male, Hirayu, Japanese Alps, Shinano, July 27, 1929 (*J. Machida*). Allotype, female, Norikuradake, Japanese Alps, July 26, 1929 (*J. Machida*).

Heterangæus laticincta is evidently most closely allied to *H. japonicus* (Alexander) from which it differs in the large size, darkened areas on pleura, and details of venation and wing pattern. The allotype female has a weak adventitious crossvein in cell R_1 immediately distad of the angulation of R_{2+3} and another in cell R_5 just beyond the fork of M_{1+2}.

HEXATOMINI

LIMNOPHILA MUNDELLA sp. nov.

General coloration black, the mesonotum subnitidous; pleura heavily pruinose; halteres yellow; wings brownish yellow, the base and costal region brighter yellow; cell M_1 about twice its petiole; m-cu beyond midlength of cell 1st M_2.

Female.—Length, about 7.5 millimeters; wing, 6.5.

Rostrum and palpi black. Antennæ with the scapal segments black, the flagellum brown; flagellar segments oval, gradually decreasing in size outwardly. Head black, sparsely pruinose, especially in front.

Pronotum black, pruinose. Mesonotum black, subnitidous, the surface only vaguely pruinose. Pleura heavily pruinose. Halteres yellow. Legs with the coxæ and trochanters gray pruinose; remainder of legs broken. Wings (Plate 1, fig. 13) with a strong brownish yellow tinge, the costal and prearcular regions brighter yellow; stigma oval, pale brown, a little deeper than the ground color; veins brown, brighter in the flavous areas. Venation: Sc_1 ending shortly before fork of Rs, Sc_2 near its tip; R_2 a trifle longer than R_{1+2}; cell M_1 about twice its petiole; m-cu beyond midlength of cell 1st M_2

Abdomen with the tergites black, sparsely pruinose; sternites brownish gray. Ovipositor with the valves elongate, blackened.

Habitat.—Japan (Honshiu).

Holotype, female, Norikuradake, Japanese Alps, Shinano, July 26, 1929 (*J. Machida*).

Limnophila mundella is generally similar to the Nearctic *L. munda* Osten Sacken. In the absence of the male sex I hesitate to refer the species to the subgenus *Prionolabis* where it will probably be found to belong. It is readily told from all other Japanese species of *Prionolabis* with cell M_1 present by the small size and unpatterned wings.

LIMNOPHILA NESONEMORALIS sp. nov.

Belongs to the *nemoralis* group; wings gray, in male not evidently widest opposite vein 1st A; male hypopygium with the gonapophyses appearing as spatulate blades.

Male.—Length, about 5 millimeters; wing, 6 to 6.5.

Female.—Length, about 5.5 to 6 millimeters; wing, 5.5 to 6.5.

Rostrum dark brownish gray; palpi black. Antennæ with the basal segment black, the flagellum brown. Head gray, the orbits broadly more whitish gray.

Mesonotum brownish gray, the præscutum with an intermediate pair of darker brown stripes, the lateral stripes scarcely evident. Pleura gray. Halteres relatively elongate, yellow, the knobs very slightly darkened. Legs with the coxæ and trochanters yellow; femora yellow, the tips slightly darkened; remainder of legs yellow, the tarsi deepening to brown; segments of legs rather conspicuously hairy. Wings (Plate 1, fig. 14) of male not noticeably widest opposite vein 1st A, as is the case in *L. subnemoralis;* brownish gray, the stigma a little darker; veins pale brown. Venation: Sc$_1$ ending about opposite the fork of R$_{2+3+4}$, Sc$_2$ a variable distance from its tip; R$_2$ faint; cell M$_1$ small, as in the group.

Abdomen brown, the subterminal segments of male not suddenly blackened, as is the case in *subnemoralis.* Male hypopygium (Plate 2, fig. 42) with the outer dististyle, *od,* conspicuously bifid at apex. Gonapophyses, *g,* appearing as flattened spatulate blades, the tips obtusely rounded.

Habitat.—Formosa.

Holotype, male, Shinten, December 3, 1928 (*S. Issiki*). Allotopotype, female. Paratopotypes, 5 males and females.

Limnophila nesonemoralis is very similar to *L. inaequalis* Alexander (Formosa) but has the gonapophyses very different in structure.

ERIOCERA CÆSAREA sp. nov.

Head black; thorax entirely dark brown, opaque; halteres dark brown; wings suffused with brown, deepest along the outer costal margin; cell M$_1$ deep; cell 1st M$_2$ small and nearly square; abdominal segments one and five to nine inclusive black, segments two to four orange-yellow.

Male.—Length, about 25 millimeters; wing, 23.5; antenna, about 6.

Rostrum and palpi black. Antennæ 7-segmented, relatively short, as shown by the measurements; flagellar segments decreasing in length and diameter outwardly, densely set with semierect setæ; scapal segments black; flagellum yellowish brown, the outer segments darker. Head dull black; vertical tubercle entire.

Thorax entirely dull chocolate brown to dark brown, the præscutum with four glabrous stripes that are slightly brighter in color. Halteres dark brown. Legs with the coxæ and trochanters dark brown; remainder of legs brownish black (only a single, posterior, leg remains, tarsi broken). Wings (Plate 1, fig. 15) with a strong brown suffusion, the costal region darker brown, especially on the distal half; extensive paler discal streaks before cord; anal cells pale, especially basally; veins brownish yellow. Venation: Sc_1 angulated and weakly spurred at extreme tip; Rs very long, about one-third longer than R; R_{2+3+4} subequal to basal section of R_5; R_{2+3} about two-fifths R_{1+2}; cell M_1 deep, nearly three times its petiole; cell 1st M_2 small and nearly square; m-cu about one-third longer than the distal section of Cu_1, some distance beyond the fork of M.

Abdomen with the basal segment brownish black, its caudal margin narrowly yellow; segments two to four bright orange-yellow; segment five black, the disk suffused with orange; remainder of abdomen, including the hypopygium, velvety black.

Habitat.—China (Szechwan).

Holotype, male, Kwanshien, altitude 1,800 to 3,500 feet, 1924 (*D. C. Graham*). Type in the collection of the United States National Museum.

By Edwards's key[2] the present species runs to couplet 41, agreeing most closely with *E. nigripennis* de Meijere, a quite distinct species. The fly appears to be most nearly allied to the later-described *E. prælata* Alexander, differing in the pattern of the body, wings, and legs.

ERIOPTERINI

NEOLIMNOPHILA PICTURATA sp. nov.

General coloration black, pruinose; halteres yellow; legs black; wings pale cream color, with a heavy dark brown pattern, including broad seams along cord and some of the longitudinal veins, and large rounded clouds at origin of Rs, fork of R_{3+4} and fork of M_{1+2}; r-m connecting with Rs before fork; R_2 nearly twice its own length before the fork of R_{3+4}.

Male.—Length, about 6.5 millimeters; wing, 8.5.

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[2] Ann. & Mag. Nat. Hist. IX 8 (1921) 70–78.

Rostrum and palpi black. Antennæ black throughout; fusion segment involving four segments and a partial fifth; outer flagellar segments elongate-oval, the verticils shorter than the segments. Head dark gray.

Thoracic dorsum black, with a very sparse gray pollen. Pleura more heavily pruinose. Halteres yellow. Legs with the coxæ pruinose; remainder of legs black. Wings (Plate 1, fig. 16) pale cream color, with a heavy dark brown pattern, arranged as follows: Cell C; cell Sc except base and apex; stigma; broad seams along cord and outer end of cell 1st M_2; continuous brown seams along veins R_5, outer sections of veins M_3, M_4, Cu, and 2d A; large rounded clouds at origin of Rs, fork of R_{3+4}, crossing the adjoining cells to vein R_5 and fork of M_{1+2}; the following veins are not seamed with dark, except as noted above: Rs, R_3, R_4, M and its branches, with the exception of the outer sections of M_3 and M_4, and 1st A; prearcular region more yellowish; veins pale yellow, darker in the infuscated areas. Venation: Sc_1 ending about opposite r-m, Sc_2 at its tip; Rs strongly arcuated at origin; r-m connecting with Rs before the fork of latter; R_2 only about one-half R_{3+4}; cell R_3 relatively small, vein R_3 being a little more than one-half R_4; cell 1st M_2 elongate; m-cu about two-thirds its own length beyond the fork of M.

Abdomen, including the hypopygium, black. Male hypopygium with the basistyles broken beyond base.

Habitat.—China (Szechwan).

Holotype, male, Mupin, altitude 3,500 feet, June 30, 1929 (*D. C. Graham*). Type in the collection of the United States National Museum.

The only allied species is *N. fuscinervis* Edwards (Yunnan), which differs in the wing pattern and venation. In addition to the seamed veins of *fuscinervis*, the present species has large rounded clouds at origin of Rs, and at forks of R_{3+4} and M_{1+2}; r-m connects with Rs before the fork and R_2 is far before the fork of R_{3+4}.

TEUCHOLABIS (TEUCHOLABIS) SCITAMENTA sp. nov.

General coloration yellow and blue-black; three nearly confluent black stripes on præscutum, the lateral pair reaching the margins of the sclerite; wings yellowish with a restricted dark pattern; male hypopygium very simple, the styli terminal in position, the outer dististyle a pale ribbonlike blade.

Male.—Length, about 6 millimeters; wing, 5.8 to 6.

Female.—Length, about 6.5 millimeters; wing, 6 to 6.3.

Rostrum brown, a little longer than the remainder of the head; palpi black. Antennæ with the scape yellowish brown; flagellum light brown, the outer segments darker; flagellar segments short-oval, with a dense white pubescence. Head dull black, heavily pruinose, especially in front.

Pronotum orange-yellow. Mesonotal præscutum yellow with three extensive blue-black stripes that are confluent behind or nearly so; lateral stripes reaching the lateral margin of præscutum, leaving a narrow yellow area behind at the suture; humeral region more orange-yellow; median region of scutum and the scutellum testaceous-yellow; scutal lobes blackened; postnotum black. Pleura yellow, the anepisternum, dorsal pteropleurite and the pleurotergite blue-black, the sternopleurite more reddish brown, the two areas separated by a narrow yellow longitudinal stripe that is densely white pubescent. Halteres black, the outer half of knob orange-yellow. Legs with the coxæ and trochanters orange-yellow; fore femora with more than the distal half black, the base yellow; middle femora yellow; posterior femora yellow, the tips narrowly brownish black; fore tibiæ and tarsi black; middle and hind tibiæ yellow, narrowly blackened at bases; tarsi obscure yellow, the apices of segments one and two and all of outer segments blackened. Wings (Plate 1, fig. 17) broad, yellowish, the costal region brighter yellow; stigma brown; a narrow brown seam on anterior cord; a very broad and diffuse slightly darker clouding occupies the central part of the region before the cord; veins yellow, darker in the infuscated areas. Venation: Sc_1 ending at near midlength of Rs, Sc_2 far from its tip; Rs nearly straight on basal half; R_{2+3+4} subequal to or shorter than R_2; vein 2d A curved strongly into the anal margin of wing.

Abdomen black, the bases of the second and succeeding segments in male yellow, the black of the outer tergites sending cephalad a median spur that becomes larger on outer segments so as finally to isolate the yellow to lateral areas on the subterminal segments; hypopygium small, dark brown. Abdominal tergites of female uniformly blackened, only the genital segment orange, the sternites with more yellow. Male hypopygium (Plate 2, fig. 43) unusually small and simple. Basistyle, *b*, short and broad. Outer dististyle, *od*, a pale ribbonlike blade. Inner dististyle, *id*, a flattened blade that terminates in a blackened beak, the outer angle with three long setæ. Phallosome in slide mounts large.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 4,500 feet, August 12, 1929 (ex Parish). Allotopotype, female, August 18, 1929. Paratopotype, female, August 22, 1929.

Teucholabis scitamenta is distinct from all regional species in the features above listed. The structure of the male hypopygium is unusually simple, more so than in any regional species known to me.

ERIOPTERA (ERIOPTERA) BREVIRAMA sp. nov.

General coloration reddish brown; head black, the orbits narrowly marked with silver; pleura iridescent blue; knobs of halteres darkened; wings brownish yellow; male hypopygium with the tergite emarginate; inner dististyle with two divergent arms.

Male.—Length, about 4.6 to 5 millimeters; wing, 4.5 to 5.

Female.—Length, about 5.5 to 6 millimeters; wing, 5.5 to 5.8.

Rostrum and basal segments of palpi yellow, the outer segments darker. Antennæ brownish black, the basal segments a very little paler. Head black, the orbits with a narrow silvery line.

Mesonotum reddish brown, the median region darker, the humeri brighter; scutellum dark brown, narrowly bordered by pale; postnotum dark gray. Pleura almost entirely covered by an iridescent blue pruinosity. Halteres pale, the knobs infuscated. Legs relatively long and stout; coxæ and trochanters yellow; remainder of legs yellow, the terminal tarsal segments infuscated. Wings (Plate 1, fig. 18) with a strong brownish yellow tinge, the costal region clearer yellow; veins light brown, more yellowish in the costal region. Venation: Distal section of Cu_1 and 2d A strongly sinuous on distal portion.

Abdominal segments chiefly dark brown, the caudal margins somewhat brightened; hypopygium obscure yellow. Male hypopygium (Plate 2, fig. 44) with the tergite shallowly emarginate, the median region not convexly produced as in *E.* (*E.*) *ornatifrons*. Dististyles almost as in *ornatifrons*, entirely glabrous, the branches of the inner dististyle, *id*, shorter and more nearly equal, the outer arm not subtended on its basal third by a pale flange but with a conspicuous flattened structure near the fork of the style.

Habitat.—China (Szechwan).

Holotype, male, Mount Omei, altitude 4,500 feet, July 31, 1929 (ex Parish). Allotopotype, female, August 11, 1929. Paratopotypes, 4 males and females, August 10 to 20, 1929.

Most closely allied to *E.* (*E.*) *ornatifrons* Edwards (Ceylon), differing most evidently in the structure of the male hypopygium.

ERIOPTERA (ILISIA) MACHIDAI sp. nov.

General coloration brown; antennal flagellum brownish yellow; wings yellowish gray, with a very sparse pale brown pattern, including vague clouds at Sc_2, R_2, tip of R_{1+2} and along cord; Sc_1 longer than Rs; cell 1st M_2 moderately elongate; anal veins gradually diverging.

Female.—Length, about 4.5 millimeters; wing, 4.6.

Rostrum and palpi brown. Antennæ with the basal segments dark brown, the flagellum paling to yellow or brownish yellow. Head grayish brown.

Pronotum brown, the anterior lateral pretergites light yellow. Mesonotum brown, the præscutum a little paler laterally. Pleura light brown, the dorsopleural region pale yellow. Halteres pale yellow, the knobs with golden-yellow setæ. Legs with the coxæ and trochanters yellow; femora brownish yellow, the tips a little darkened; tibiæ and tarsi obscure yellow, the latter passing into brown. Wings (Plate 1, fig. 19) yellowish gray, the base and costal region a trifle more yellowish; a very sparse and vague pale brown pattern, including clouds at Sc_2, R_2, and tip of Sc_1, and tip of R_{1+2}, the latter two areas delimiting the ends of a yellowish stigmal area; cord vaguely seamed with dusky; veins very pale brown, the macrotrichia darker. Venation: Sc_1 elongate, exceeding Rs; Sc_2 about opposite one-sixth the length of Rs; cell 1st M_2 moderately elongate; m-cu before the fork of M; vein 2d A nearly straight, the anal veins gradually diverging.

Abdomen dark brown. Ovipositor with the valves very long and slender, pale yellow.

Habitat.—Japan (Honshiu).

Holotype, female, Hirayu, Japanese Alps, Shinano, July 27, 1929 (*J. Machida*).

I take great pleasure in naming this very distinct species in honor of my friend Dr. Jiro Machida, to whom I am indebted for many Japanese Tipulidæ. *Erioptera machidai* is very different from the remaining species of the subgenus *Ilisia* described from eastern Asia. It is more closely allied to *E. maculata* and allies than to the species centering about *E. areolata* Siebke.

ORMOSIA GRAHAMI sp. nov.

Size very large (wing, female, 10 millimeters); general coloration gray, the præscutum with three confluent black stripes; halteres light yellow; legs black; wings white, with a heavy dark brown pattern that appears chiefly as seams along the veins; veins R_3 and R_4 deflected strongly cephalad at outer ends; a weak spur at near two-thirds the length of vein R_4, directed into cell R_4; cell 1st M_2 closed; vein 2d A very strongly sinuous.

Female.—Length, about 8.5 millimeters; wing, 10.

Rostrum and palpi black. Antennæ black throughout; flagellar segments oval, with relatively short verticils, these becoming smaller and less conspicuous on the outer segments. Head blackish, the orbits gray.

Mesonotal præscutum with the disk chiefly covered by three confluent black stripes, the ground color restricted to the humeral and lateral portions; pseudosutural foveæ black; scutum gray, the lobes chiefly blackened; posterior sclerites of mesonotum black, sparsely pruinose. Pleura black, pruinose. Halteres entirely light yellow. Legs with the coxæ black, pruinose; remainder of legs black. Wings (Plate 1, fig. 20) white, with a heavy dark brown pattern; prearcular region and an oval area in cells C and Sc before the stigma light yellow; the brown areas include most of cells C and Sc and very conspicuous seams along most of the longitudinal veins, in cell M_4 so broad as to restrict the ground color to a long-oval area; a cross-fascia in cell 1st A at about two-thirds the length; veins brown, more flavous in the yellow areas. Macrotrichia of cells corresponding in color to the areas occupied, being white, brown, and golden. Venation: R_2 just before fork of R_3 and R_4, the two latter veins deflected strongly cephalad at their outer ends; vein R_3 strongly looped on distal half; R_4 with a spur at two-thirds the length, directed into cell R_4; cell 1st M_2 closed; vein 2d A very strongly sinuous.

Abdomen grayish black, with sparse yellow setæ. Ovipositor with the valves horn yellow, the tergal valves blackened basally.

Habitat.—China (Szechwan).

Holotype, female, Mupin, altitude 3,500 feet, June 30, 1929 (*D. C. Graham*). Type in the collection of the United States National Museum.

Ormosia grahami is named in honor of the Reverend David C. Graham, who has added materially to our knowledge of the fauna and flora of Szechwan and eastern Tibet. It is a strikingly distinct fly that requires no comparison with any known species, being the largest and most conspicuously patterned form so far discovered.

MOLOPHILUS FEROX sp. nov.

Belongs to the *gracilis* group; general coloration light brown; head gray; male hypopygium with unusually complicated armature, including a spinous rod arising from the outer portion of the basistyle, together with three dististyles, one of which is bifid.

Male.—Length, about 4.5 millimeters; wing, 5.

Rostrum and palpi black. Antennæ broken. Head gray.

Pronotum blackish. Mesonotum light brown, the pleura somewhat darker, the ventral sternopleurite and meron more testaceous brown. Halteres chiefly pale, the base of the stem restrictedly yellow, the stem dusky, the large knobs yellowish brown. Legs with the coxæ and trochanters yellowish testaceous; remainder of legs pale brown, the tarsi passing into brownish black. Wings grayish, the veins darker; macrotrichia long, dark brown. Venation: R_2 lying distad of r-m; m-cu a little less than one-half the petiole of cell M_3; vein 2d A of moderate length.

Abdomen brown, the sternites somewhat paler, the conspicuous genitalic styli black. Male hypopygium (Plate 1, fig. 45) with the outer lobe of the basistyle, *b*, produced into a long sinuous rod that is subequal or longer than the dististyle, on outer margin at near one-third the length with an acute yellow spine; distal two-thirds of the rod narrower, the surface more roughened; ventral surface of basistyle with a slender fingerlike lobe. Three dististyles, *d*, the longest a curved sinuous smooth rod, the distal portion bent at about a right angle into a long straight spine. Second dististyle conspicuously bifid. Third dististyle more basal in position, inserted in the notch of the basistyle, a simple blackened rod, the basal half a little thicker, the gently curved distal half narrower. Ædeagus long, narrow, yellow.

Habitat.—Japan (Honshiu).

Holotype, male, Norikuradake, Japanese Alps, Shinano, July 26, 1929 (*J. Machida*).

Molophilus ferox is very distinct from all other regional species of the genus in the structure of the male hypopygium.

ILLUSTRATIONS

[Legend: *a*, ædeagus; *b*, basistyle; *d*, dististyle; *g*, gonapophysis; *id*, inner dististyle; *od*, outer dististyle; *s*, sternite; *t*, tergite.]

PLATE 1

FIG. 1. *Tipula exusta* sp. nov., venation.
2. *Tipula nippoalpina* sp. nov., venation.
3. *Tipula latiflava* sp. nov., venation.
4. *Cylindrotoma nigripes* sp. nov., venation.
5. *Phalacrocera megacauda* sp. nov., venation.
6. *Limonia* (*Dicranomyia*) *subpulchripennis* sp. nov., venation.
7. *Limonia* (*Euglochina*) *dignitosa* sp. nov., venation.
8. *Antocha* (*Antocha*) *minuticornis* sp. nov., venation.
9. *Antocha* (*Antocha*) *nebulipennis* sp. nov., venation.
10. *Tricyphona pectinata* sp. nov., venation.
11. *Tricyphona setipennis* sp. nov., venation.
12. *Heterangæus laticincta* sp. nov., venation.
13. *Limnophila mundella* sp. nov., venation.
14. *Limnophila nesonemoralis* sp. nov., venation.
15. *Eriocera cæsarea* sp. nov., venation.
16. *Neolimnophila picturata* sp. nov., venation.
17. *Teucholabis* (*Teucholabis*) *scitamenta* sp. nov., venation.
18. *Erioptera* (*Erioptera*) *brevirama* sp. nov., venation.
19. *Erioptera* (*Ilisia*) *machidai* sp. nov., venation.
20. *Ormosia grahami* sp. nov., venation.

PLATE 2

FIG. 21. *Dolichopeza* (*Nesopeza*) *subgeniculata* sp. nov., male hypopygium, ninth tergite.
22. *Dolichopeza* (*Nesopeza*) *subgeniculata* sp. nov., male hypopygium, outer dististyle.
23. *Dolichopeza* (*Nesopeza*) *subgeniculata* sp. nov., male hypopygium, inner dististyle.
24. *Tipula exusta* sp. nov., male hypopygium, lateral aspect.
25. *Tipula exusta* sp. nov., male hypopygium, ninth tergite.
26. *Tipula exusta* sp. nov., male hypopygium, dististyle.
27. *Tipula nippoalpina* sp. nov., male hypopygium, lateral aspect.
28. *Tipula nippoalpina* sp. nov., male hypopygium, ninth tergite.
29. *Tipula depressa* sp. nov., male hypopygium, ninth tergite.
30. *Tipula depressa* sp. nov., male hypopygium, outer dististyle.
31. *Tipula depressa* sp. nov., male hypopygium, inner dististyle.
32. *Tipula depressa* sp. nov., male hypopygium, lobe of eighth sternite.
33. *Tipula depressa* sp. nov., male hypopygium, gonapophysis.

FIG. 34. *Tipula politostriata* sp. nov., male hypopygium, outer dististyle.
35. *Tipula politostriata* sp. nov., male hypopygium, inner dististyle.
36. *Tipula politostriata* sp. nov., male hypopygium, gonapophysis.
37. *Tipula angustiligula* sp. nov., male hypopygium, lateral aspect.
38. *Tipula angustiligula* sp. nov., male hypopygium, ninth tergite.
39. *Tipula angustiligula* sp. nov., male hypopygium, lobe of ninth sternite.
40. *Antocha (Antocha) minuticornis* sp. nov., male hypopygium.
41. *Antocha (Antocha) nebulipennis* sp. nov., male hypopygium.
42. *Limnophila nesonemoralis* sp. nov., male hypopygium.
43. *Teucholabis (Teucholabis) scitamenta* sp. nov., male hypopygium.
44. *Erioptera (Erioptera) brevirama* sp. nov., male hypopygium.
45. *Molophilus ferox* sp. nov., male hypopygium.

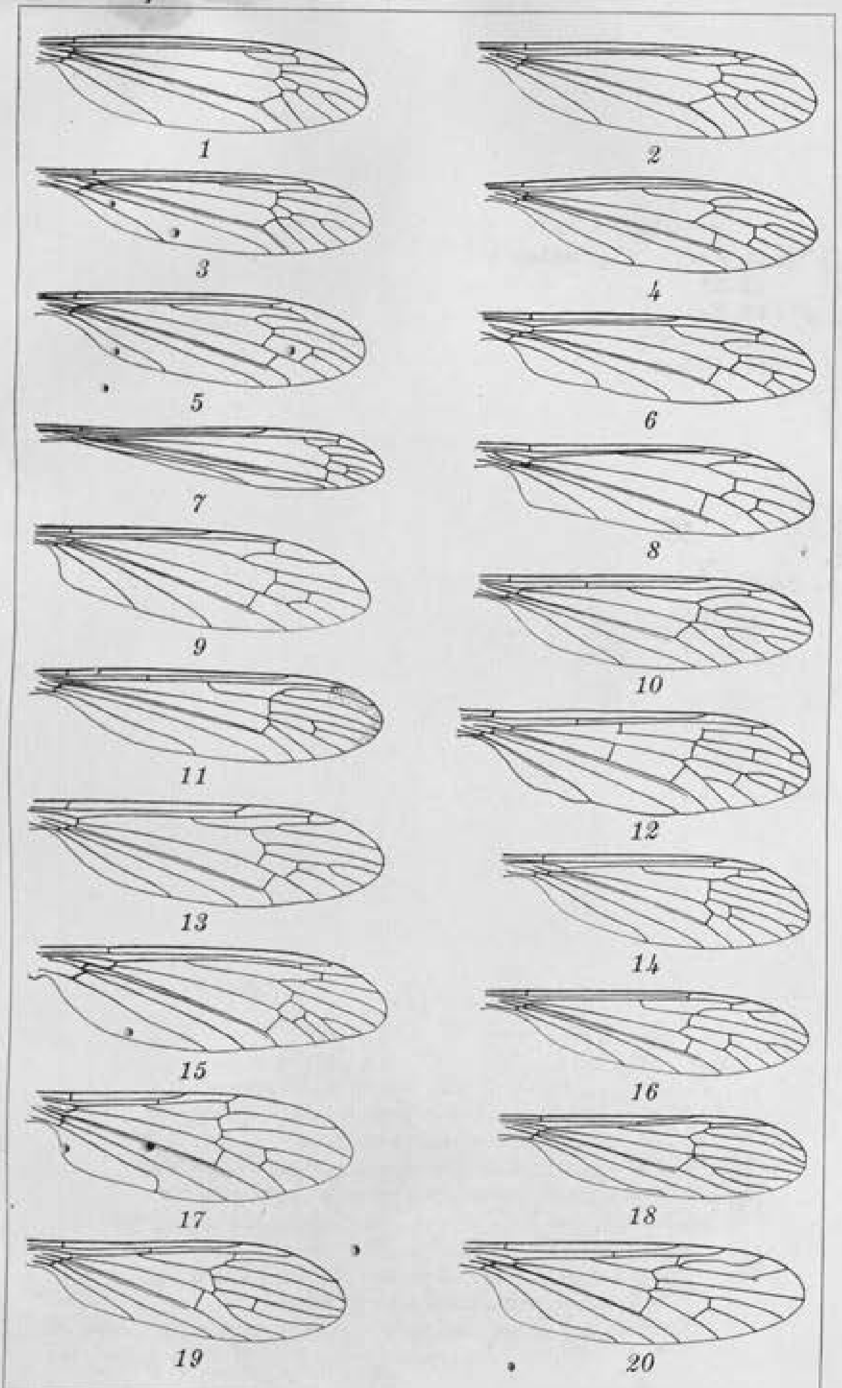

PLATE 1.

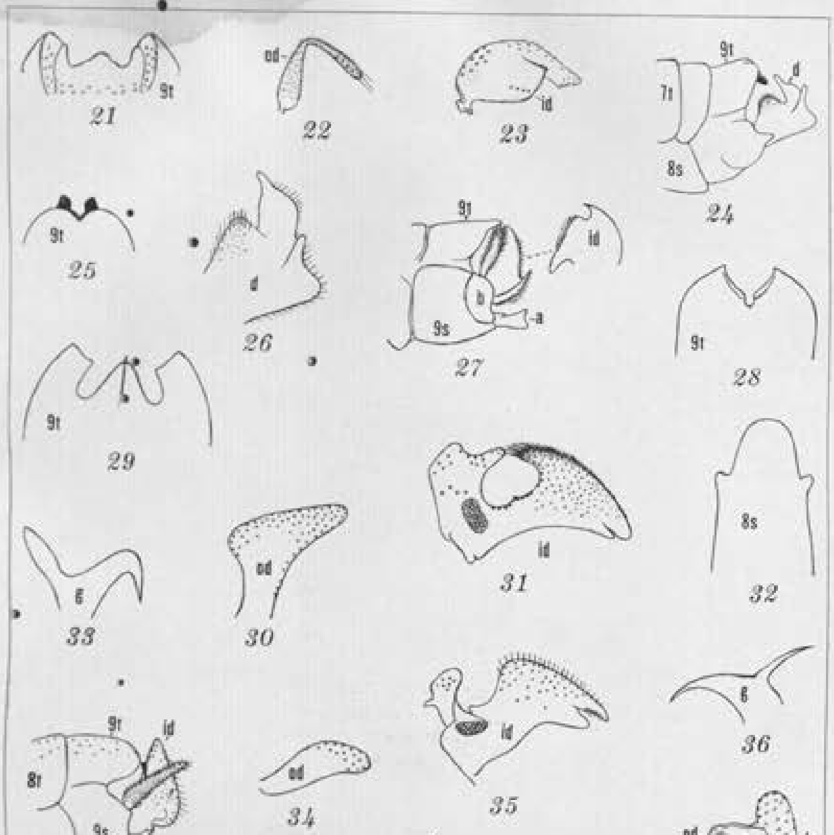
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PLATE 2.